PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. III. 1855–56. No. 46.

SEVENTY-THIRD SESSION.

Monday, 26th November 1855.

DR CHRISTISON, Vice-President, in the Chair.

The following Council were elected :—

President.

SIR T. MAKDOUGALL BRISBANE, BT., G.C.B., G.C.H.

Vice-Presidents.

Sir D. BREWSTER, K.H.	Dr CHRISTISON.
Very Rev. Principal LEE.	Dr ALISON.
Right Rev. Bishop TERROT.	Hon. Lord MURRAY.

General Secretary,—Professor FORBES.

Secretaries to the Ordinary Meetings,—Dr GREGORY, Dr BALFOUR.

Treasurer,—JOHN RUSSELL, Esq.

Curator of Library and Instruments,—Dr TRAILL.

Curator of Museum,—JAMES WILSON, Esq.

Counsellors.

Dr GEORGE WILSON.	Colonel MADDEN.
CHARLES MACLAREN, Esq.	JAMES CUNNINGHAM, Esq.
Rev. Dr ROBERT LEE.	Dr GREVILLE.
Prof. C. PIAZZI SMYTH.	A. KEITH JOHNSTON, Esq.
Hon. B. F. PRIMROSE.	Dr MACLAGAN.
Sir WILLIAM GIBSON-CRAIG, Bart.	WILLIAM SWAN, Esq.

Monday, 3d December 1855.

RIGHT REV. BISHOP TERROT in the Chair.

The following Communications were read:—

1. On the Occurrences of the Plague in Scotland during the Sixteenth and Seventeenth Centuries. By Robert Chambers, Esq.

In this paper the author adduced, from contemporary chroniclers and diarists, all the visits of the Pest or Plague which occurred in Scotland after 1560; namely, in the years 1568, 1574, 1585, 1587, 1597, 1607, 1622, and 1645. He cited, from the same sources of information, the notable instances of scarcity and famine; namely, 1563, 1568, 1574, 1578, 1587, 1596, 1598, 1612, 1622, 1642–3. It thus appeared, that while there were several instances of famine not followed by the Pest, there was scarcely one instance of the Pest which was not immediately preceded by a famine. So far the opinion of modern medical writers, that deficient nutrition in the community is one of the predisposing causes of pestilential fevers, may be considered as borne out by facts.

2. On a Problem in Combinations. By Professor Kelland.

This was a problem proposed some years ago by Professor Forbes, when discussing the question of the distribution of the stars. Simple as it is, no prior notice seems to have been taken of it, nor is the author aware that the full solution has yet been given. The problem is this:—"There are n dice, each of which has p faces, p being not less than n; it is required to find the number of arrangements which can be formed with them; 1*st*, "that no two shall show the same face; 2*d*, that no three shall show the same face, and so on." The only part of this problem of which the solution has yet appeared is the first, and the result is $p\,(p-1)\,\ldots\,(p-n+1)$. The author supplies the solution of the remaining portions.

3. Occurrence of Native Iron in Liberia, in Africa. From a Letter of Dr A. A. Hayes, Chemist, Boston, U. S., to Professor H. D. Rogers. Communicated by Dr Gregory.

Dr Hayes states that there is evidence establishing the fact that *pure native* iron exists abundantly in the country back from the central part of the colony of Liberia. Early travellers state that the natives of Africa find iron *ore* so pure, that they heat and hammer it into form. Explorations by the Liberians show that the inhabitants of towns are engaged in manufacturing iron, and an intelligent native has recently shown how it is done. Last year a mass was sent home by a working blacksmith, who cut it with a chisel from a mass of larger size connected with rock. This proved to be native iron, malleable and ductile, yet unequal in its molecular structure. The general arrangement of the particles is unlike that of any artificial iron known, and there are among the iron particles of crystalline and transparent quartz, octahedral crystals of magnetic oxide of iron, and one of the silicates of soda and lime. No traces of carbon exist in connection with it, and no piece of artificial iron has yet reached Dr Hayes which *does not contain carbon.* When analysed by Dr Hayes' mode of electrolysis, it rapidly shows points which are positive to the surrounding portions, and, the action proceeding, the mass becomes honeycombed in texture, while the final chemical result is—

Pure iron, ...	98·40
Quartz, magnetic oxide iron, and silicate lime,	1·60
	100·

The positive points are the crystalline aggregates of the simple minerals, the iron in immediate contact being more open in texture, and always positive in relation to the crystals which are negative.

Professor Rogers supported the view taken by Dr Hayes of the genuinenèss of the alleged native iron from Africa, by testifying to the experience of that chemist in the technical examination of manufactured iron, and by the statement of his belief, derived from a comparison of many analyses, that the presence of carbon in an iron is the best test of its having been artificially brought to the metallic state. The reputed telluric iron of Canaan in Connecticut, is almost

the only instance in which an alleged native iron has been reported to have been met with, not in loose masses, but in the form of a mineral lode, that of Canaan being stated to be a true vein two inches thick in mica slate. The detection of carbon in this iron proves the specimens to be spurious, and confirms an impression long prevalent among American mineralogists, that the original statement about this vein was founded either in mistake or fraud. An examination of the best authenticated records of native telluric iron tends certainly to reduce the number of the genuine instances, if we accept the carbon test; yet the authorities for the existence of such are too many and too respectable to justify the general incredulity in regard to the presence of native iron on our globe. The statement that this African iron is manufactured in seven villages, is an intimation that it exists in considerable quantity, more than would be compatible with the supposition that it is merely a large mass of meteoric iron. But the fact, particularly significant, against its being native meteoric iron, is the total absence of nickel from its composition, as shown in the full analysis given by Dr Hayes. The absence of carbon indicates it not to be of human fabrication; that of nickel proves it not to be meteoric. Should it really be shown, by further exploration, to exist in quantity, its occurrence on the frontier of a Liberian colony, by presenting another incentive to the settlement of that region by civilized men pursuing the arts of peace, cannot but be regarded as full of good omen for the cause of humanity in Africa.

The following Gentlemen were duly elected Ordinary Fellows:—

JAMES HAY, Esq., Leith. | R. M. SMITH, Esq.

The following Donations to the Library were announced:—

Transactions of the Royal Scottish Society of Arts, Vol. IV., Part3. 8vo.—*From the Society.*

The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. (N.S.) Nos. XLIX, L. 8vo.—*From the Society.*

Transactions of the Architectural Institute of Scotland. Session, 1854–5. 8vo.—*From the Institute.*

Proceedings of the Royal Society, Vol. VII., No. 14. 8vo.—*From the Society.*

Results of Astronomical Observations, made at the Observatory of the University, Durham, from October 1849 to April 1852, under the general direction of the Rev. Temple Chevallier, B.D., F.R.A.S. By R. C. Carrington, Esq., B.A., F.R.A.S. 8vo.—*From the Observatory.*

The Assurance Magazine, and Journal of the Institute of Actuaries. Vol. V., Part 4; Vol. V. Part 1. 8vo.—*From the Institute.*

Journal of the Statistical Society of London. Vol. XVIII., Parts 1, 2, 3. 8vo.—*From the Society.*

The Quarterly Journal of the Geological Society. Vol. II., Parts 1, 2, 3. 8vo.—*From the Society.*

The Journal of the Horticultural Society of London. Vol. IX. Part 4. 8vo.—*From the Society.*—

Monthly Notices of the Royal Astronomical Society. Vol. XIV. 8vo. *From the Society.*

The Journal of the Royal Geographical Society. Vol. XXIV. 8vo. —*From the Society.*

The Journal of the Royal Asiatic Society of Great Britain and Ireland. Vol. XV., Part 2. 8vo.—*From the Society.*

Journal of the Geological Society of Dublin. Vol. VI. Part 2. 8vo. —*From the Society.*

The Quarterly Journal of the Chemical Society. Vol. VIII., Part 2. 8vo.—*From the Society.*

Notices of the Meetings of the Members of the Royal Institution of Great Britain. Part V.—*From the Institution.*

Proceedings of the Liverpool Literary and Philosophical Society. Session 1854-5. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal. Nos. 70, 71, 72. 8vo. —*From the Society.*

Abstracts of the Proceedings of the Ashmolean Society. Vols. I. II. III., Part 1. 8vo.—*From the Society.*

Memoirs of the Literary and Philosophical Society of Manchester. 2d Series, Vol. XI., XII. 8vo.—*From the Society.*

The American Journal of Science and Arts. Conducted by Prof. Silliman and Dana. Nos. 57, 58, 59. 8vo.—*From the Editors.*

Collection of Charts published at the Hydrographic Office, London. 8vo.—*From the Admiralty.*

Ornithological Synonyms, by the late Hugh Edwin Strickland, M.A. Edited by Mrs H. E. Strickland and Sir W. Jardine, Bart. Vol. I. 8vo.—*From the Editors.*

Astronomical Observations, made at the Radcliffe Observatory. By Manuel J. Johnstone, M.A., 1850, 1851, 1852. 8vo.—*From the Observatory.*

Archæologia, or Miscellaneous Tracts relating to Antiquity, published by the Society of Antiquaries of London. Vol. XXXI. 4to.—*From the Society.*

Proceedings of the Society of Antiquaries of London. Vol. III. No. 52. 8vo.—*From the Society.*

Descriptive and Illustrated Catalogue of the Histological Series contained in the Museum of the Royal College of Surgeons of England. Prepared for the Microscope. Vol. II. 4to.—*From the College.*

Assault of Sevastopol. Two Topographical and Panoramic Sketches, representing the advanced lines of attack, and the Russian defences, in front of Sevastopol, with a description and remarks. The sketches by Capt. M. A. Biddulph, R.A. Fol. 2 copies. *From Capt. Younghusband.*

Transactions of the Zoological Society of London. Vol. 4, Parts 2, 3. 4to.—*From the Society.*

The Origin and Progress of the Mechanical Inventions of James Watt, illustrated by his correspondence with his friends, and specification of his patents. By James Patrick Muirhead, Esq., M.A., 3 vols. 4to.—*From the Author.*

Researches on Colour Blindness, by George Wilson, M.D., 8vo.—*From the Author.*

Magnetical and Meteorological Observations made at the Hon. East India Company's Observatory, Bombay, in the year 1851. 4to. —*From the Hon. East India Company.*

Astronomical and Magnetical, and Meteorological Observations made at the Royal Observatory, Greenwich, in the year 1853. 4to. —*From the Observatory.*

Memoirs of the Royal Astronomical Society. Vol. XXIII., 4to.—*From the Society.*

Abstracts from the Meteorological Observations taken at the Stations of the Royal Engineers in the year 1853–4. Edited by Lieut. Col. H. James, R.E. 4to.—*From the Editor.*

Papers read at the Royal Institute of British Architects. Session 1854–5. 4to.—*From the Institute.*

Memoir of Robert Troup Paine. By his Parents. 4to.

Materia Medica and Therapeutics. By Martyn Paine, M.D. 12mo.

The Institutes of Medicine. By Martyn Paine, M.D. 8vo.

Medical and Physiological Commentaries. By Martyn Paine, M.D. 3 Vols. 8vo.

A Discourse on the Soul and Instinct. By Martyn Paine, M.D. 18mo.

Reports and State Documents published by the Senate of Washington.—*From the Senate of Washington.*

Documents relating to the Colonial History of the State of New York. Vols. III. and IV. 4to.—*From the State of New York.*

Smithsonian Contributions to Knowledge. Vol. VII. 4to.

Smithsonian Report. On the Construction of Catalogues of Libraries, and a General Catalogue. 8vo.

Eighth Annual Report of the Board of Regents of the Smithsonian Institution.—*From the Institution.*

Bulletins de l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique. Tome XXI., 2me Partie. Tome XXII. 1re Partie. 8vo.—*From the Academy.*

Essai d'une Géographie Physique de la Belgique. Par J. C. Houzean, 8vo.—*From the Author.*

Mémoires Couronnés et mémoires des savants étrangers, publiées par l'Académie Royale de Belgique. Tome VI., 2me Partie. 8vo. —*From the Academy.*

Nachrichten von der Georg-Augusts-Universität und der Königl. Gesellschaft der Wissenschaften zu Göttingen. 1854. Nos. 1–17. 12mo.—*From the Society.*

Annalen der Königlichen Sternwarte bei München. VII. Band. 8vo.

Jahresbericht der Münchener Sternwarte für. 1854. 8vo.—*From the Observatory.*

Monatsbericht der Königl. Preus, Akademie der Wissenschaften zu Berlin, August, December. 1854. 8vo.—*From the Academy.*

Abhandlungen der Mathematisch-physikalischen Classe der Koeni-

glich Bayerischen Akademie der Wissenschaften. VII. Bd., 2 Abtheil. 4to.

Abhandlungen der Historischen Classe der Koeniglich Bayerischen Akademie der Wissenschaften. VI. Bd., 2 Abtheil. 4to.—*From the Academy.*

Preisschriften gekrönt und herausgegeben von der Fürstlich Jablonowskischen Gesellschaft zu Leipzig. No. 5. 8vo.—*From the Society.*

Nova Acta Academiæ Cæsareæ Leopoldino-Carolinæ Naturæ Curiosorum. Vol. 24, Pars 2. 4to.—*From the Academy.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Bd. VIII.

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Bd. XIV. and Bd. XV. Heft 1 and 2. 8vo.

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Philosophische historische Classe. Bd. XIV. and Bd. XV. Heft 1. 8vo.

Almanach der Kaiserlichen Akademie der Wissenschaften. 1855. 12mo.—*From the Academy.*

Monday, 17*th December* 1855.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. Geological Notes on Banffshire. By R. Chambers, Esq., F.R.S.E., &c.

The author described the succession of pleistocene beds at Gamrie, on the coast of Banffshire, as follows (ascending order):—1, boulder clay; 2, a thick bed of sand; 3, a thin bed of brick clay; 4, a thick bed of sand; 5, a thick bed of brick clay; 6, a bed of sand, containing shells of arctic character entire; 7, a moderately thick bed of pure clay; 8, a thick bed of sand; 9, a thin bed of ferruginous gravel (which Mr Chambers regards as the equivalent of the upper till, or coarse gravel, of other geologists); 10, a thick bed of soft blue clay; 11, a thick mass of sand rising to the top of an eminence on which is a vitrified fort. Owing to the great scale on which the formation is presented, and the clearness of the section exposed towards the sea, this is an unusually favourable situation for studying the

Scottish pleistocenes. The shells are the well known *Astarte arctica, Natica clausa, Tellina proxima, &c.*

At Stracheres, on Kineddart Water, six miles inland, the same shells are found in the boulder clay, in a broken state; and opposite Kineddart Castle near by, they are found entire in a sand-bed about thirty feet above the rock, and overlaid with the same ferruginous gravel.

The noted clay bed, containing boulders with lias fossils, at Blackpots, near Banff, Mr Chambers considers as one of the brick clay beds.

At this latter situation the author found a large terrace or ancient sea margin at 64 or 65 feet above the present sea level, and corresponding in elevation to one seen in various other parts of the island. He traced an alluvial terrace of very conspicuous appearance, at about 167 feet above the sea, along both sides of the Deveran River and the minor vale of Turreff, the town of Turreff being seated on it. Another, somewhat higher, is equally prominent in the Kineddart valley.

In the Deveran valley, opposite to Eden Castle, Mr Chambers discovered what he regards as a fine example of an ancient moraine. It commences at the border of a tributary rivulet at Auchinbeddie, and curves for a mile upwards along the hill side, forming an irregular ridge of detrital matter about thirty feet high: the other wing of the same moraine is traceable on the other side of the rill. The little valley of the tributary stream has been the bed of the glacier by which this moraine was formed. On the surface, at short intervals, are flat indentations, surfaced with alluvial matter, and corresponding in level with the two terraces; so that they may be assumed as having been formed by the sea, when it was at the corresponding relative levels.

The author connected this fact of a submergence posterior to the period of local glaciers, with the fact, which he had ascertained in Arran, that that period again was subsequent to a former submergence, during which the noted terrace of erosion round the west coast of Scotland (twenty-five feet above the present sea level) was formed; and, seeing it thus proved that the period of local glaciers was one of elevation, inferred that the cause of the lower temperature of that era was simply our mountain valleys being raised within the region of the snow line.

2. On the Physical Geography of the Old Red Sandstone Sea of the Central District of Scotland. By Henry Clifton Sorby, F.G.S. Communicated by Professor Balfour.

The author endeavours to show that in the Old Red Sandstone period there extended across Scotland a branch of the sea or strait, whose northern shore was somewhere in the line of the mica schist rocks which extend from Aberdeen to the mouth of the Clyde, and its southern in the direction of the Greywacke rocks that run across from St Abb's Head to Wigtonshire. In this, at the earlier part of the period, there were considerable tidal currents; but when the upper beds were deposited, they were more or less completely absent, and there were present such as were chiefly due to the action of the wind.

He shows that there is a most intimate connection between the physical geography of a sea and the currents present in it, and that even their directions and characters can be ascertained from the structures produced in the deposits formed under their influence; therefore, the physical geography of our ancient seas may be inferred within certain limits.

He applies these general principles to the facts seen in the Old Red Sandstone of Scotland, and endeavours to show that the appearances presented indicate the effects of tidal oscillations.

The Council announced that it had awarded the Keith Prize for the Biennial Period ending April 1855, to Dr Thomas Anderson for his Papers on the Crystalline Constituents of Opium, and on the Products of the Destructive Distillation of Animal Substances, both printed in the *Transactions*.

The following Donations to the Library were announced:—

Jahresbericht über die Fortschritte der reinen, pharmaceutischen und technischen Chemie, &c. Herausg. von Liebig und Kopp. 1854. 8vo.—*From the Editors.*

Die Fortschritte der Physik in den Jahren, 1850, 1851, 1852. Dargestellt von der Physikalischen Gesellschaft zu Berlin. 8vo. —*From the Society.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Bd. XV., Heft. 2 & 3; Bd. XVI Heft. 1. Philosophisch-Historische Classe. 8vo.

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Bd. XV. Heft. 3; Bd. XVI. Heft. 1. 8vo.—*From the Academy.*

Abhandlungen der Philosoph.—Philologischen Classe der Koeniglich Bayerischen Akademie der Wissenschaften. Bd. XVII., 2 Abtheil. 4to.

Denkrede auf die Akademiker Dr Thaddäus Liber und Dr Georg Simon Ohm, von Dr Lamont. 4to.

Almanach der Königlich Bayerischen Akademie der Wissenschaften, für das Jahr 1855. 12mo.—*From the Academy.*

Archives du Muséum d'Historie Naturelle-publiées par les professeurs-administrateurs de cet établissement. Tome VII. Liv., 3 & 4; Tome VIII., Liv. 1 & 2. 4to.—*From the Museum.*

Aanteekeningen van het verhandelete in de Sectie Vergaderingen van het Provinciaal Utretsch Genootschop van Kunsten en Wetenschappen. 1845–54. 8vo.

Verhandeling over de verdiensten van Gijsberet Karel van Hogendorp, als Stautshuishoudkundige ten aanzien van Nederlands, door M. O. Van Rees. 8vo.

Description de l'Observatoire météorologique et magnétique à Utrecht. Par P. W. C. Krecke. 8vo.—*From the Academy.*

Astronomical and Meteorological Observations made at the Radcliffe Observatory in the year 1853, under the superintendence of Manuel J. Johnson. M.A. Vol. XIV. 8vo.—*By the Trustees.*

Memorie della Accademia delle Scienze dell' Istituto di Bologna. Tomo V. 4to.—*From the Academy.*

Journal of the Asiatic Society of Bengal. Nos. 3 & 4. 1855. 8vo. —*From the Society.*

Almanaque Nautico para el ano 1856, calculado de orden de J. M. en el Observatoro de Marina de la Ciudad de San Fernando. 8vo.—*From the Observatory.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. 1854. Nos. 2, 3, and 4. 8vo.—*From the Institute.*

Bulletin de la Société de Géographie. 4ieme Serie. Tom. 8 and 9. 8vo.—*From the Society.*

Berichte über die Verhandlungen der Königlich Sächsischen Gesellschaft der Wissenschaften zu Leipzig. 1854–5. 8vo.—*From the Society.*

Bulletin de la Société Impériale des Naturalistes de Moscou. 1853. Nos. 3 and 4. 1854. No. 1. 8vo.—*From the Society.*

Medico-Chirurgical Transactions. Published by the Royal Medical and Chirurgical Society of London. Second Series. Vol. XX. 8vo.—*From the Society.*

Journal of the Ethnological Society of London. Vols. I. II. III. 8vo.—*From the Society.*

Transactions of the Pathological Society of London. Vol. VI. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XVIII. Part 4. 8vo.—*From the Society.*

Observations Météorologiques faites à Nijné Tagulsk (Monts Oural). Governement de Perm. 1850–51–52–53. 8vo.

Collection of Naval Charts from the *Depôt General de la Marine.* 8vo.—*From the French Government.*

Verhandelingen der Koninklijke Akademie van Wetenschappen. 2de Deel. 4to.

Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen. 2de Deel. 3de Stuk. 3de Deel. 1ste & 2de Stuk. 8vo.

Catalogus der Boekeri van de Koninklijke Akademie van Wetenschappen, gevestigd te Amsterdam, 1ste Afler. 8vo.—*From the Academy.*

Analytisch-geometrische Untersuchungen über Allgemeine Verwandtschafts-Verhältnisse von Coordinaten-Systemen. Von J. G. H. Swellengoebel. 4to.—*From the Author.*

Kongl. Vetenskaps Akademiens Handlingar. 1853. 8vo.

Kongl. Vetenskaps Akademiens Ofversigt. 1854. 8vo.

Kongl. Vetenskaps Akademiens Arsberättelser af Wikström 8vo.

Kongl. Vetenskaps Akademiens Arsberättelser af Boheman. 8vo. —*From the Academy.*

Memorie della Reale Accademia delle Scienze di Torino. Tome XIV. 4to.—*From the Academy.*

Mémoires de l'Académie Royale des Sciences, des Lettres et des Beaux Arts de Belgique. Tomes XXVIII. XXIX. 4to.—*From the Academy.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch Naturwissenschaftliche Classe. Bd 9. 4to.

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Philosophisch Historische Classe. Bd 6. 4to.

Jahrbüchr der K. K. Central-Anstalt für Meteorologie und Erdmagnetismus. Von Karl Kreil. III. Bd. 1851. 4to.—*From the Academy.*

Bulletin der Königl. Akademie der Wissenschaften (München). Nos. 1–52. 4to.—*From the Academy.*

Compte rendu Annuel, par le Directeur de l'Observatoire Physique Central, A. T. Kupffer. 1853. 4to.—*From the Editor.*

Della vita e delle opere di Guido Bonatti, Astrologo ed Astronomo del secolo decimoterzo notizie raccolte da B. Boncompagni. 8vo.—*From the Author.*

Annuaire de l'Académie Royale des Sciences, &c. de Belgique. 1854–55. 12mo.

Académie Royale de Belgique, Bibliographie Académique. 1854. 12mo.

Annuaire de l'Observatoire Royal de Bruxelles. 1854–55. 12mo.

Almanach Seculaire de l'Observatoire R. de Bruxelles. 1854. 12mo.—*From the Academy.*

Monday, 7th January 1856.

DR CHRISTISON, Vice-President, in the Chair.

Professor Christison, in delivering the Keith Medal to Dr Anderson of Glasgow, made the following remarks:—

Dr Anderson—It is a peculiar pleasure to me to be the organ of the Society this evening for presenting to you this token of the approbation of this Society and its Council.

As there must be many now present who are unacquainted with the origin, conditions, and mode of adjudication of the Keith Prize, I hope that others will bear with me for a moment till I state these very briefly. The prize was founded by the late Sir Alexander Keith of Dunottar and Ravelston, to be given to the author of the best paper read in this Society during each successive biennial period. The Council were appointed to administer the fund, and to adjudicate the prize. The adjudication is determined by advice of a committee of the Council specially nominated for the purpose. Having been a member of the Council almost since the foundation of the prize, and repeatedly a member of the Prize Committee, I can testify to the exceeding care, and anxiety, and impartial disposition of the Com-

mittee and Council on all occasions. The best proof, perhaps, to this effect is that their award, so far as I am aware, has never been subjected to challenge in the public prints; nor have I ever heard it criticised even in private society. A still more satisfactory proof, as some may think, is the eminence of the men to whom the prize has hitherto been awarded. The first was awarded in 1828 to Sir David Brewster; the next to Mr Graham, now Master of the Mint; Sir David Brewster then received it a second time; our much esteemed secretary, Professor Forbes, has been twice similarly honoured; another was awarded to Mr Scott Russell for his researches on the "Wave-theory;" another to Mr Shaw for his experiments on the development and growth of the salmon, which have yielded since most important practical results; another to our revered president—whose duty I am now, in his unavoidable absence, inadequately discharging—for his laborious and munificent "Magnetical Observations;" and the last awards were to Professor Kelland and Mr Macquorn Rankine for elaborate and important mathematical investigations. I do not state these facts for the sake of taking any credit to the Council for the discharge of a duty, but in order that Dr Anderson himself, as well as his fellow-members of this Society, may duly appreciate that gentleman's honourable exertions, which have yielded results entitling him to be similarly rewarded on the present occasion, and to be associated with such predecessors.

Among the previous awards I may be permitted, I hope, to advert to certain circumstances connected with the last adjudication of the Keith Prize for a chemical paper—namely, to Mr Graham in 1834, for his admirable researches on the "Law of the Diffusion of Gases." For it was this paper, and in some measure the reading of it in this Society, which laid the foundation of his fortunes. The paper excited intense interest at the time in the Society, both among scientific members and others; and his name in consequence became well known to many. It may not perhaps be known to Mr Graham himself, but when he was a candidate for the chair of chemistry in University College, London, reference was made by the College authorities to several Fellows of this Society; and I have reason to know that the unanimous opinion, greatly deduced from his paper, and expressed in reply to these inquiries, had much to do with his appointment to succeed the late

Dr Turner. The present is only the second occasion, and after an interval of twenty-one years, that the prize has been assigned for a chemical paper. I do not know what the chemists have been about in the interval, but it is to be hoped that they may now be stimulated by Dr Anderson's successful example.

It is usual for one in my present position to give some account of the researches for which the prize has been adjudicated by the Council. This, however, I will, I daresay, be excused for not attempting. The papers—for they are two in number—are on "the Products of the Destructive Distillation of Organic Substances," and on "the Crystalline Bodies obtained from Opium." I find it impossible to give an adequate analysis of these papers which would not be too tedious for delivery now. In fact, they are scarcely capable of abbreviation, and must be perused in their entire state, in order to be followed. In the course of his experiments on both subjects, Dr Anderson has examined a great many bodies previously known, and discovered others of great scientific interest, and ascertained the composition of all, notwithstanding that they are all of great complexity. I must be satisfied with merely informing that great proportion of his fellow-members who may find it difficult to follow his elaborate researches, that they belong to the most recondite and difficult department of chemical analysis. It has happened that, with only one or two exceptions, the Keith Prize has been assigned to authors who have not only written each a paper of high merit, but have likewise contributed many others of value to our proceedings. So it is in the present instance. Dr Anderson, when a very young chemist, communicated to the Royal Society his first paper in 1842, only one year after his graduation, on the analysis of two zeolitic minerals; and we have been favoured by him with many other excellent researches since. But his last are the most elaborate and productive.

I have said that both topics of these papers belong to the most recondite branch of chemical analysis. There are not wanting people who regard such difficult inquiries slightingly, because they do not lead to any apparent practical results of importance. You will hear such recondite researches characterized as *difficiles nugæ*, and very lightly esteemed accordingly. But in these days no one who respects himself will fall into so gross an error. Dr Anderson's researches are all concerned with great che-

mical laws, and bodies developed in consequence of the existence of them. These laws exist, because they were established by Providence; and we may depend upon it that they were not established without a purpose, and that a beneficent one. Permit me to give a proof of this. The great discovery of the existence of the vegetable alkaloids, commenced nearly forty years ago, belonged in its day to one of the most abstruse departments of chemical analysis. There are others besides myself in this room who may remember that for some years afterwards the successive discovery of these bodies was lightly spoken of as *difficiles nugæ*—or laborious trifling. But a different view came to be taken of such inquiries, when it appeared that all the vegetable alkaloids concentrate in themselves the poisonous and medicinal properties of the vegetables which yield them. Among the truly practical and beneficent results that have ensued, let me mention one great fact—namely, that with one of these alkaloids, intermittent fever, one of the most common diseases of hot and even of some temperate climates, may be cured with almost as great certainty as we can appease hunger with bread or with meat. I shall detain you by mentioning only one other illustration—the newest of all. In the course of a very elaborate inquiry in a far-removed corner of organic chemistry, a body was discovered which is known to chemists by the scientific name of terchloride of formyl. This was in 1832. For many years it belonged to the *difficiles nugæ;* no one even saw it, except occasionally some chemist more curious than his fellows in general. I venture to say that many here present do not know the name, and may think it requires the alchemy of Dr Anderson, and such as he, to understand it. At last, after the lapse of fifteen years, this was discovered to be the powerful agent which has since been more familiarly known by its oldest name chloroform, one of the kindest gifts of Providence to man. Let all beware, then, of speaking lightly of the elaborate and apparently unproductive chemical researches of the present day. Who knows but that among the curious new bodies discovered by Dr Anderson, there may yet be found another gift not inferior to that of chloroform, or that of quina?

I set out with observing, Dr Anderson, that it was a peculiar pleasure to me to be honoured with the duty of presenting this prize. It would be a great pleasure in any circumstances, but it is peculiarly so when I have to convey this impartial mark of our

Society's respect to one who, once my pupil, and afterwards my friend, is now also my professorial brother. It is well known to your early friends that it would have been easy for you, under the auspices of your late father, to have soon attained a competence and independence as a medical practitioner; but you preferred the more thorny path of science. I happen to know that your choice gave some uneasiness and anxiety to your parent, when he reflected how few,—alas! for the scientific welfare of this country,—how very few prizes in chemical science are held out to its votaries in Britain. But he was reassured by the assurance of his friends that the spark so clearly visible would soon be blown into a flame; and, accordingly, he lived long enough to see you received by universal consent among the chemists of Europe, and rewarded by the second—if, indeed, it be only the second—chemical office, in point of honour in Scotland.

I must not conclude without mentioning that the value of the Keith Prize is not be measured by this medal merely. Apart from the honour, the prize varies in value from £50 to £65, and the latter sum is its amount on the present occasion. It is, therefore, in all respects, an object well worthy of competition among scientific men.

The following Communications were then read :—

1. Geometry, a science purely experimental. By Edward Sang.

After remarking that the perfect strictness of the demonstrations in Geometry is generally admitted, the author of the paper cited the almost universal belief in the soundness of Euclid's reasoning as a notable example of wide-spread credulity. He then enunciated the proposition that our knowledge of the truths of geometry is altogether derived from experience.

Taking the first of Euclid's problems, "To construct an equilateral trigon," he showed that the facts that the circles intersect at all, and that they have only one intersection on each side of the base, are taken for granted, and he contrasted the looseness of this procedure with the hypercritical precision of the following problem "to cut from the greater of two lines a part equal to the less."

Proceeding from the propositions to the axioms, he denied that the human mind possesses the innate power of perceiving a general truth: and asserted that, without a knowledge of all the cases to which a statement may be made to apply, we are not safe in enunciating it; thus, adopting the definition of equality as implied in Euclid's eighth axiom, the proposition "if equals be added to equals the sums are equal," is not true; the sums may be equal or they may be equivalent. And, as an instance of the ease with which we may be led to admit the truth of a specially worded proposition, he cited this one:—"perfect equality implies equality in size, in shape, in weight, in colour, and in every respect in which we can compare them, so that of two perfectly equal bodies, the one could not be distinguished from the other; perfect equality, then, must include every inferior degree of resemblance." Such is an axiom to which most people would assent as self-evident—yet it is not true.

Even the axiom "things equal to the same thing are equal to each other," is not to be admitted without examining the particular kind of equality implied; for though bodies similar to the same body be similar to each other, and those equivalent to the same equivalent to each other, solids symmetric to the same solid are not symmetric to each other.

Passing from the axioms to the definitions, he pointed out the necessity of establishing the possibility of the thing defined: thus if we form such a nomenclature as this; a solid with four trigonal faces is called a tetrahedron, a solid with five trigonal faces is called a pentahedron, one with six trigonal faces a hexahedron, and so on, our definitions would be essentially vicious, since no such pentahedron can exist; and thus we see that our definitions of the tetrahedron and hexahedron are only admissible after examination.

Again it is necessary to take care that the definition of one object be consistent with that of another. Thus, having defined a straight line, we are not at liberty to use the straight line in defining a plane surface until we have made sure that this use is consistent with what has already been predicated. Now the ordinary definition of a plane surface is, that *the straight line joining any two points in it lies wholly on the surface.* This definition, however, implies a very abstruse property of straight lines; namely, that if two straight lines be drawn from one point, and if two points be assumed in each of them, the two straight lines joining alternately the

remote point on the one line with the near point on the other cross each other. Until the truth of this proposition shall have been demonstrated we are not at liberty to define a flat surface. This demonstration can only be obtained by experiment, and, therefore, it was concluded, all our knowledge of geometry being founded on this proposition, is experimental.

2. Notice respecting recent Discoveries on the Adjustment of the Eye to Distinct Vision. By Professor Goodsir.

The question as to the arrangement by means of which the eye is adapted for distinct vision at different distances has for two centuries strongly attracted the attention of physiologists. The numerous hypotheses, and untenable theories which have been advanced on this subject are all, however, more or less unsatisfactory. They are severally based on

1. The mere structure or form of the refractive humours of the eye;
2. A presumed process connected with change in the direction of the axis of vision;
3. The movements of the iris;
4. Change in the position of the retina;
5. Change in the position of the lens;
6. Change of form of the cornea;
7. Change of form of the lens.

This important question has now been definitively determined by the researches of Dr Cramer of Groningen, detailed in a prize treatise submitted to the Dutch Association for the advancement of medical science in 1851; but, which, except in the form of a short abstract at the time, was only published at a later period. In 1853, Helmholtz also announced to the Berlin Academy the same discovery, reached independently, and by a method more complex than that employed by Cramer.

The entire question had been previously simplified by the conclusion to which Volkmann had come, that the eye, when in a passive condition, is adapted for the vision of distant objects, the foci of convergent pencils being then situated in the retina; that when it requires to be adjusted for a near object, an active process of accommodation is set up, which brings the foci forward to the nervous

membrane; and that the return to the passive condition, which again adapts the eye to distant objects, is a passive process, following on the previous effort.

Cramer had therefore only to determine the nature of the active change, by means of which the foci, for a near object, are brought forward to the retina. Now, as Helmholtz had shown, that the adaptation of the eye to distance must depend upon a change of some kind in the refractive condition of the humours of the organ; and as Senff had previously proved that no change takes place in the curvature of the cornea; and as the ingenious theories of Ludwig and Stellwag had in no way removed the difficulties involved in explaining how the lens can be moved forward; there remained only, as a basis for investigation, the hypothesis of a change of form of the lens. This hypothesis, as Volkmann had stated, could only be objected to as insufficient; but not as involving any contradiction of fact; and might be verified by more careful and extended observation.

The question, therefore, which Cramer had to determine, was this—is the form of the lens changed in the adaptation of the eye to near objects?

Cramer was indebted to Donders for the fundamental idea on which he proceeded in the solution of this question. Donders had previously entered on the investigation, but had failed in his observations. He is entitled, however, to the credit of having suggested the employment of the experiment of Purkinje in this inquiry; and of having subsequently elucidated its successful results.

Cramer has discovered that in the adjustment of the eye for a near object, there takes place a change in the form of the lens, consisting of an increase in the curvature of its anterior surface, produced by the iris and ciliary muscle, but without alteration in the position of the lens itself; while the return to its original form for the vision of a distant object is the effect of its own elasticity, which in proportion to the pressure applied, had co-operated in producing the increase of its anterior convexity. He ascertained the occurrence of this alteration of form by watching, through an arrangement of his own contrivance magnifying from 10 to 20 diameters, the change which takes place in the image of the flame of a candle reflected from the anterior surface of the lens during the adjustment of the eye to a near object. The eye having been adjusted to a distant object, and the erect image from the surface of the cornea having been brought nearly to the

margin of the iris in the pupil, the erect image from the front of the lens will be observed deeper and less distinct, a little beyond the centre of the pupil, and the small distinct inverted image from the back of the lens will be close to the opposite margin of the iris. The eye being now adjusted to a near object, the deep erect image advances, diminishes, becomes more distinct, and moves across the centre of the pupil to the immediate neighbourhood of the corneal image.

This change in the relative position of the three images was correctly considered by Cramer as a distinct evidence of an increase in the curvature of the anterior surface of the lens. It would appear, however, that he was not entitled to conclude, as he did, from the immobility of the inverted image, that no change occurs in the posterior curvature of the lens. Donders, in reference to this has asserted, that the immobility of the inverted image affords satisfactory evidence that a change does actually occur in the curvature of the posterior surface of the lens; and Stellwag has demonstrated that a change of this kind must necessarily take place. That there is a contemporaneous increase in the curvature of both surfaces of the lens must be admitted from the consideration that if such a change did not occur in the posterior surface, the increased curvature of the anterior would necessarily produce a change in the position of the inverted images; which is not the case. The optical effect of the increase of anterior curvature masks the slight movement of the inverted image.

The alteration in the curvature of the posterior surface is, however, so slight, that we may safely assume that the essential alteration takes place in the anterior surface.

Helmholtz has proved that the anterior curvature of the lens is increased during adjustment of the eye to near objects, by measuring accurately the distance between the images of the flames of two candles reflected from that surface, in the active and passive conditions of accommodation. According to his calculations the radius of curvature of the anterior surface is, for distant vision, from 10 to 11 millimetres; for near vision about 5 millimetres.

A change in the form of the lens having thus been ascertained to be the mode of adjustment of the eye to distances; the next point to be determined is the mechanism by which the change of form is effected.

It may be stated generally, that although the structures which act

upon the lens have been ascertained, the details and arrangements of the process itself still require elucidation.

Cramer removed the eye of a seal immediately after the death of the animal, and exposed a portion of the surface of the vitreous body at the back of the organ. He then introduced the electrodes of an electro-magnetic rotation apparatus into the opposite attached margins of the iris. The flame of a candle at the distance of 35 centimeters from the cornea was distinctly observed on the vitreous surface, with a microscope magnifying 80 diameters. At each passage of the electrical current through the organ, the pupil contracted, the image of the flame became broader, less distinct, and less definitely outlined. This effect was visible to the naked eye, and indicated the probability of the form of the lens being altered by the contraction of the muscular structures in the interior of the eye. Cramer ascertained that the iris is at least the principal agent in producing the change ; for when a cataract needle was introduced so as to divide the iris, and produce a complete coloboma, the focus was no longer affected by the electrical current. Cramer also removed the cornea, annular ligament, and iris, after which the electrical current produced no change in the adjustment; although the ciliary processes were observed to be put upon the stretch. The lens was also shown by numerous experiments to be incapable of changing its own form. It is not muscular ; for when the recent lens was removed from the eye, and the flame of a candle brought to a focus through it, on a piece of oiled paper, the electrical current produced no change in the adjustment.

Cramer concludes, in this department of his subject, that the iris and ciliary muscle alter the form of the lens. The ciliary muscle contracting pulls the ciliary processes forward, and so prevents the lens from receding under the pressure of the iris. The latter produces the change in the anterior curvature, by a primary contraction of its circular fibres; followed up by contraction of its radiating fibres, which, from being curved forwards, become straight, and thus pressing on the marginal portion of the anterior surface of the lens, force the central portion forwards. Cramer's explanation of the action of the iris on the lens is based on Stellwag's recent assertion, that the posterior chamber has no existence, but that the iris rests immediately on the front of the lens, the ciliary processes, and the zonule of Zinn, so that it projects like a dome into the ante-

rior chamber. The pressure is thus communicated by the iris to the lens through the medium of the ciliary processes, zonule of Zinn, and contents of the canal of Petit, the lens being supported and kept forward by cotemporaneous contraction of the ciliary muscle. Donders is inclined to believe that a very thin layer of fluid is interposed between the iris and the structures behind it; but practically Cramer's opinion appears to be correct.

Hueck, in attempting to explain ocular adjustment by the movement of the lens by the iris, had stated that when viewed in profile, the iris is seen to project into the anterior chamber during vision of a near object. Volkmann denied this; but the fact is undoubted; and Helmholtz has ascertained that the protrusion is about $\frac{1}{3}$ millimetre.

Ruete has objected to Cramer's conclusion as to the agency of the iris in altering the form of the lens, on the ground that in cases of congenital deficiency of the iris the power of adjustment is not deficient. In such instances some compensating arrangement must exist.

Senile Presbyopia mainly depends, according to Cramer, on the diminished muscular contractility of the iris and ciliary muscle. Myopia, again, on diminution of the elasticity of the capsule of the lens, which disables the lens from regaining its normal form after each act of adjustment. He denies that the curvature of the cornea is increased in myopia, and states that the apparent increase is due to the continued increased protrusion of the iris into the anterior chamber.

The following Gentleman was duly elected an Ordinary Fellow:—

David Bryce, Esq., Architect.

Monday, 21st January 1856.

Colonel MADDEN, Councillor, in the Chair.

The following Communications were read:—

1. Memoir of Rear-Admiral Sir John Franklin. By Sir John Richardson, C.B. Communicated by Professor Balfour.

2. On the Geological Relations of the Secondary and Primary Rocks of the Chain of Mont Blanc. By Professor Forbes.

This paper* is intended to meet the objections taken by Mr D. Sharpe, in a paper published in the *Quarterly Journal of the Geological Society for February* 1855, to the views of the present writer, and those of several eminent geologists, on the structure of the chain of Mont Blanc.

De Saussure first described the singular superposition of gneiss to limestone which occurs on the south-east side of the valley of Chamouni, a testimony the more clear from its obvious opposition to the Wernerian views of the period.

M. Necker, grandson of De Saussure, in a remarkable paper on the granite of Valorsine, published in 1828, presents a section of the south-east slopes of the valley of Chamouni, which exhibits the limestone dipping under the gneiss, the beds of which gradually become steeper as we approach the centre of the chain. The facts were still more emphatically stated by the same author in a work on the Geology of the Alps, published thirteen years later.

In 1842, Professor Forbes paid particular attention to the structure of *both* sides of the chain of Mont Blanc; and pointed out the precise analogy of the superposition of gneiss to limestone on the Italian, to that on the Swiss side of the mountain. He indicated very distinctly two localities, one on each side of the Alps, where the superposition might be distinctly seen and traced for some distance.

Mr Sharpe, in the paper referred to, having treated the descriptions of De Saussure and of M. Necker as vague or contradictory, the present writer defends them. And he repels Mr Sharpe's objection to his own conclusions as not based on sufficiently definite indications of the localities, by citing the passages from his *Travels in the Alps*, where he has specified them, and by showing that other geologists have satisfactorily verified his observations.

He next quotes the testimony of M. Favre of Geneva, and of M. Studer of Berne, as having from personal observation of the closest kind, been led to conclusions identical with his own.

* It will be printed at length in the *Edinburgh New Philosophical Journal for April* 1856.

Finally, he gives examples from the writings of M. Elie de Beaumont of similar anomalous superpositions in the Alps of Dauphiné, and in the writings of M. Hugi and M. Studer, of others in the Canton of Berne, which would leave the fact in question still to be accounted for, even if all geologists from the time of De Saussure had been in error as to the particular constitution of the chain of Mont Blanc.

The paper was illustrated by sections showing the views of successive geologists.

The following Gentlemen were duly elected Ordinary Fellows:—

W. Mitchell Ellis, Esq.
Dr G. J. Allman, Prof. Nat. History, Edinburgh.

Monday, 4th February 1856.

Right Rev. Bishop TERROT, V.P., in the Chair.

The following Communications were read:—

1. On the Turkish Weights and Measures. By Edward Sang, Esq.

In this paper a short account was given of the comparison of the oka with the imperial grain weight, and of the arsheen with the inch.

The oka was stated to be 19,807 grains, so that 18 cantar of 44 oka each make one ton one pound.

The length of the arsheen was determined by comparison with the ebony standard of Sultan Selim.

The extreme length, as obtained by contact, was 29·890 inches, but the ends had evidently been tampered with; on that account the divisions of the rod were referred to; these gave results varying from 29·944 to 29·949, and therefore the mean, 29,946 inches, may be taken as the true length of the Turkish arsheen.

2. Observations on *Polyommatus Artaxerxes*, the Scotch Argus. By Dr W. H. Lowe.

Polyommatus Artaxerxes, or the Scotch Argus, is an insect not only of great local interest, but has attracted, and continues to

attract, the notice of entomologists all over the world. Among the English, and still more among the foreign students, who annually throng our University, there are always a considerable number who arrive in Edinburgh anxious to see "the rare butterfly from Arthur's Seat," or who are commissioned by entomological friends to obtain it. Besides, there are the still more destructive emissaries from the London and provincial dealers in insects, who infest the hill during the season in which it is found. But although the situation in which this insect is principally taken is extremely circumscribed, I am not aware that its numbers are materially diminished by this continuous drain upon them. The new road now in contemplation beneath "Samson's Ribs," and through the village of Duddingston, will, I fear, go far to exterminate it, as it will pass, I believe, through the exact spot upon which it is found, and to which it is in a singular degree limited.

The first published account we have of this insect is by Fabricius, in his "*Systema Entomologiæ*," 1793, under the name "*Lycæna Artaxerxes*," in which he states its habitat to be "Anglia," but without any special reference to Scotland. He does this on the authority of Mr Jones of Chelsea, in whose cabinet a specimen then existed; but it would appear that Fabricius himself never saw the insect, as it was at that time a frequent custom to insert in entomological cabinets a painted piece of card, to supply the place of an insect then believed to be too rare to afford much probability of its being obtained. I may here mention, that naturally feeling some interest to know who this Mr Jones of Chelsea (so often quoted by authors) was, I applied to Mr James Wilson of Woodville, who most obligingly wrote to Mr Adam White, of the British Museum, and through whom we find that Mr Jones had an excellent collection of native insects, and also a number of illustrations, coloured by himself, which are still in existence; but from the higher degree of excellence now attained in such delineations, of course greatly diminished in pecuniary value, however interesting they may have been at the time alluded to. It was no doubt one of these illustrations which Fabricius availed himself of in his *Systema Entomologiæ*. We find this insect next mentioned as *Papilio Artaxerxes* by Lewen (1795), a fellow of the Linnean Society, who, like Fabricius, refers to Mr Jones' specimen, but adds, that it was taken in Scotland. In the *Natural History of Insects*, by Donovan, in 1813, we have

the first full account of this insect; and his description is so animated and enthusiastic, that the naturalists of the Society, if not the other fellows, will excuse my making one quotation from him:— "To the great astonishment of our English collectors of natural history," he says, "*Papilio Artaxerxes*, an insect heretofore of the highest possible rarity, has been lately found in no very inconsiderable plenty in Britain. For this interesting discovery we are indebted to the fortunate researches of our young and very worthy friend, W. E. Leach, Esq., who met with it common on Arthur's Seat, near Edinburgh, and also on the Pentland Hills." It will not be uninteresting to the fellows of this Society to know that Mr James Wilson was with Dr Leach on this occasion, and joined him in his entomological researches at that time. As I have entered so far into the history of this insect, I must now in fairness state, that the same authority (Donovan) mentions the existence of a specimen in the "extensive and valuable" cabinet of Mr Macleay, taken in Scotland, previous to Dr Leach's discovery. It is the same Mr Macleay whose name is associated with another interesting, but much more widely distributed insect, the *Erebus Blandina*, or Arran Argus. Donovan concludes with the remark—"As these insects fly in the daytime, there can be little doubt they may be sought for by the collectors with success on the hilly spot called Arthur's Seat, near Edinburgh."

Polyommatus Artaxerxes, thus established as a well-known British insect, appears successively in the works of Mr Stephens, 1828; Rennie (*Conspectus*), 1831; Duncan, 1837; Wood (illustrated catalogue), 1839; Westwood, 1841; and Captain Brown, 1843; but I do not think there is in these works any important addition to the information I have thus thrown together.

Having endeavoured to trace rapidly, and in a manner as little tedious as possible, the history of *P. Artaxerxes*, I may remark, that great as is the interest this insect has excited among naturalists, its habits, and especially its transformations, were until recently entirely unknown. Mr R. Logan, who resides almost on the spot on which it abounds, endeavoured some years ago, I believe, to obtain its larvæ by inclosing a number of the perfect butterflies beneath a glass frame in his garden, in the hopes that the eggs might be deposited; but as at that time it was generally believed to feed on the *Ulex europæus*, amidst which it may be seen to flit, the eggs, if deposited at all,

naturally perished for want of their proper nidus; and this laudable experiment of course failed. The same accurate and patient observer, however, subsequently arrived at the belief that the insect preferred the *Helianthemum vulgare*, which grows luxuriantly on the south side of the hill, remarking, that while the *Ulex europæus* abounded all over the hill, the butterfly did not, but was confined to the south, and only where the *Helianthemum* grew, frequently indeed in conjunction with the *Ulex*. This inference has since proved correct. So lately as 1851, Mr Logan, in an article in the *Naturalist* for March in that year, after describing the *P. Artaxerxes* as they may be seen gaily flitting over the banks of Arthur's Seat in the sunshine, or resting on the tall culms of grass and other plants while quiescent, remarks: "Strange to tell, no one knows anything of their history; where they lay their eggs, or what the larva feeds on, and where the inactive chrysalid passes the long, cold months of winter, are all in mystery;" and adds, "the discovery of the caterpillar and chrysalis is a point much to be desired." Struck with these remarks, published too just before the insect might be expected to make its accustomed annual appearance, I determined to go to Arthur's Seat for the express object of finding this long looked-for chrysalis. I spent several hours diligently examining the stems of different plants, particularly the *Ulex europæus* and the *Helianthemum vulgare;* the latter of which I frequently tore up bodily, and examined piecemeal. I did this in the belief that all the Polyommati attached their chrysalids to the stems of plants, as is indeed the usual habit of this genus, and was ignorant that any of them burrowed in the ground. My time and patience being nearly exhausted, I now began to dig in the loose earth which lies beneath the bushes of furze, the shade of which precludes anything from growing beneath them. Here I was also unsuccessful, but seeing some tufts of *Helianthemum* overhanging some barren patches of earth, I continued my examination there also, and almost immediately found several chrysalids, the appearance of which left me no doubt that they were those of *P. Artaxerxes*. The day was now declining, and I was anxious to show my acquisitions to Mr Logan, to whose house I immediately repaired. That gentleman showed the greatest interest in the discovery, and, like myself, expressed his surprise that one of the genus *Polyommatus* should bury its chrysalis in the ground instead of attaching it to the stem of a plant. He further requested me to place the chrysalids in his keep-

ing, that he might figure them for a work upon which he has long been engaged, and to which this society has become a subscriber. A few days after, I received the said chrysalids from Mr Logan, and he at the same time mentioned that, acting on the information I had given him, he had pursued the search for the chrysalids, and had found them in considerable numbers. Those I had in my own possession emerged from the chrysalis, either that day or the following; and since that time it has, of course, become easy to note the habits of *P. Artaxerxes*, and a beautiful delineation of it in all its stages of development will appear in Mr Logan's book, whenever its appearance shall realize the expectations of his numerous subscribers.

To go further into the description of its transformations at this point would be to trespass on the subsequent but as yet unpublished observations of Mr Logan, and I shall therefore leave it now, to say a few words in conclusion on *Polyommatus Agestis* and *P. Salmacis*, two insects so nearly allied to the one before us that they have been at different times considered to be one species. On looking at the drawings of these three closely allied insects, for which very faithful and beautiful illustrations I am indebted to my friend Mr Dallas, we perceive that *P. Artaxerxes* is readily enough distinguished by the conspicuous white spot in the angle of the upper wing, while *P. Agestis* has a black one in nearly the same position. These markings, though affording in themselves but slight grounds for specific distinction, are nevertheless permanent in their character, and even before we were acquainted with the caterpillars of the respective insects, gave great probability to the opinion that the two were distinct, especially when taken in conjunction with the fact that *P. Artaxerxes* is confined to Scotland and the north of England, and *P. Agestis* as exclusively to the southern counties of England. Still this was matter of opinion, and it is only now that we are enabled by our own observations in Scotland upon *P. Artaxerxes*, and almost at the same time by similar observations by Mr Harding and Mr Stainton in London upon *P. Agestis*, to determine, as I think, finally upon the specific difference of the two insects. The gentlemen I have just named have bred *P. Agestis* from the caterpillar, and find that it feeds upon *Erodium cicutarium*, a plant in natural affinity and every other respect widely removed from *Helianthemum vulgare*. When, therefore, to the slight but permanent differences of its external markings and habitat is added the fact that the caterpillar of the

one feeds upon a plant so different from the food upon which the other is found, that probably the food of the one would poison the other, it appears to me that the specific distinctions between the two insects may be regarded as established.

We have, however, *P. Salmacis* still remaining undetermined, its caterpillar and chrysalis not having as yet been found. The chief distinction to be remarked in its external character is the slight but peculiar areola of white scales which surround the black spot occupying an exactly similar position in the upper wing as in *Agestis*. Although Mr Doubleday regards this insect as a variety of *P. Artaxerxes*, I have always felt and still believe it to be much more closely allied to *P. Agestis*. During last year (1855) I visited Castle-Eden-Dene, the habitat of *P. Salmacis*, and bearing in mind my observations on Arthur's Seat, felt sure I should by digging in similar places under the tufts of *Helianthemum* find the chrysalids. In this I was unsuccessful, although the *Helianthemum* was most abundant. The spot on which *P. Salmacis* is found faces the sea (the German Ocean), and the ground is a stiff wet clay, with dense, coarse herbage, both ill suited for burying its chrysalid, if that be its habit; nor is the *Helianthemum* the *prevailing* plant there. Mr Wailes observes, that he has never found it more inland than a quarter of a mile from the sea; and although the *Helianthemum* is most abundant in the upper part of the Dene, Mr Tristram, the clergyman of the district, and other residents, assured me it was never seen except on the spot I have named, by a high cliff of clay overhanging the sea. This certainly suggests the idea of its being dependent on some littoral plant growing only within a certain range of the salt water. I observed the *Anthrocæra filipendulæ* and *Procris statices* flying in great numbers together with *P. Salmacis*, and their chrysalids attached to the stems of plants were abundant. I did not at the time know of Mr Harding's observations, and that *P. Agestis* fed upon *Erodium cicutarium*, and, consequently, did not particularly note whether that plant grew there; but having been accustomed to botanical observations all my life, I think I should certainly have noticed it if it had been the prevailing plant,—a thing, moreover, which the stiff clay soil renders improbable. What I did notice was the *Geranium sanguineum* in great quantity (the flowers filled with Ceutorhynchus geranii), a plant not far removed in natural affinity from the one I have just named. Altogether, I feel inclined to predict that *P.*

Salmacis may be found to feed on *Geranium sanguineum*, and to attach its chrysalids to the stems; but this is mere surmise, and until its transformations have been observed, it must still remain, as it now is, an undetermined species.

3. On Solar Light, with a Description of a simple Photometer. By Mungo Ponton, Esq.

The first part of this communication was occupied with a detail of some observations, made in the course of last summer, on the quantity and intensity of Solar light, as compared with familiar sources of artificial flame. The instrument employed for these observations was a simple monochromatic photometer, whose construction was minutely described.

The results obtained were stated to be, that a small surface, illuminated by mean solar light, is 444 times brighter than when it is illuminated by a moderator lamp, and 1560 times brighter than when it is illuminated by a wax candle (short six in the lb.),—the artificial light being in both instances placed at two inches distance from the illuminated surface. It was then pointed out, that as the electric light may be easily obtained of a brilliancy equal to 520 wax candles, three such electric lights, placed at two inches from a given small surface, would render it as bright as when it is illuminated by mean sunshine.

It was thence inferred, that a stratum occupying the entire surface of the sphere of which the earth's distance from the sun is the radius, and consisting of three layers of flame, each $\frac{1}{1000}$th of an inch in thickness, each possessing a brightness equal to that of such an electric light, and all three embraced within a thickness of $\frac{1}{40}$th of an inch, would give an amount of illumination equal in quantity and intensity to that of the sun at the distance of 95 millions of miles from his centre.

It was then shown, that were such a stratum transferred to the surface of the sun, where it would occupy 46,275 times less area, its thickness would be increased to 94 feet, and it would embrace 138,825 layers of flame, equal in brightness to the electric light; but that the same effect might be produced by a stratum about nine miles in thickness, embracing 72 millions of layers, each having only a brightness equal to that of a wax candle.

The various possible causes of the light proceeding from the lu-

minous envelope of the sun were then considered; and an attempt was made to show that the shining particles in that envelope may possibly be minute luminiferous organisms, floating in an elastic atmosphere, each emitting only a small amount of phosphorescence,—the enormous flood of splendour emanating from the surface of the medium being due to the combined action of these individually feeble agents.

The following Gentlemen were duly elected Ordinary Fellows:—

Hon. Lord Neaves.
Dr Penny, Glasgow.

Monday, 18*th February* 1856.

Right Rev. Bishop TERROT, V.P., in the Chair.

The following Communications were read:—

1. On certain cases of Binocular Vision. By Professor William B. Rogers. Communicated by Professor Kelland.

The object of this paper was to ascertain, by a geometrical construction, the optical appearance presented by the binocular vision of a straight line and a circle, or of two straight lines. The problem discussed was, accordingly, the geometric one of the intersection of a cone with a plane, or of two cones with each other: and the conclusion arrived at was that the apparent image is always a conic section. The author took no account of the *perspective* of the presented combination of images, nor of the union or disunion of the extremities of the respective images when their lengths are different. Nor did he allude to the mode by which the mind arrives at connected conclusions, from separate examination by the eye, whether by retention of images on the retina, or by the action of the memory, or otherwise. In anticipation of the introduction of such subjects, which the author has discussed in three papers, printed in Silliman's Journal of last year, Sir D. Brewster addressed the following letter to Prof. Kelland, which puts some of these questions in a striking point of view, and is of considerable interest:—

"My dear Mr Kelland,—I observe that Professor Rogers is to

read a paper on *Binocular Vision* at the Royal Society on Monday. As he has published his experiments and views on this subject in *three* articles in Silliman's Journal for *July*, *October*, and *November*, 1855, I presume that the paper he is about to read will contain the same views. I regret that I cannot be at the meeting on Monday to defend my theory of the Stereoscope against his objections to it; which are founded on an inaccurate perception of the phenomena, and stand in direct opposition to the *Law of Visible Direction*, which I have placed beyond a doubt, and which, I believe, is universally admitted.

"Mr Rogers maintains that *two lines* of unequal length, AB, *ab*, for example, *ab* being the shortest, can be made to coalesce perfectly, *i.e.*, that when the points A *a* are united by distinct vision, B and *b* are also united. Now, when the optical axes are converged, on A*a* *united* and seen *distinctly*, B and *b*, the other ends of the lines, are seen *indistinctly*, and, therefore, the observer cannot *see* them united, unless by running the point of distinct vision from A to B, when he will see them united. But when he is thus seeing these points B and *b* united, A and *a* have separated till the eye returns and unites them as before. This is the true process which goes on, and the *apparent* union of the lines thus effected is aided by two causes which Mr Rogers does not seem to have noticed. The eye runs from A to B and back again in less than one-third of a second (the duration of the impression of light upon the retina), so that the impression of A and *a* united *remains* when the eye is actually seeing B and *b* united. The other cause is merely an auxiliary one, and is not necessary to the *apparent* union of the line. It is the mental recollection of the union of A and *a* when the eye has passed in an instant to join B *b*. I lay no stress, however, upon this fact, as it is only a *physical* one, on the supposition that a recollected impression is the result of a visual sensation.

"If two unequal lines can be united and perfectly coalesce, then *two separate visible points* would have their pictures on the retina coincident; or, what is the same thing, a *line* joining two points, *a* and *b*, would have a *single point* for its image on the retina; and, what is still more absurd, *two different points* of the retina would have the same line of visible direction!

"When the difference between the two lines AB and *ab* exceeds a certain quantity, the apparent coalescence, produced by the causes

I have mentioned, entirely disappears, and it is then easy to convince one's self that the ends B and *b* are not only extremely indistinct, but completely separated when the optic axes are converged upon A and *a* united and seen distinctly.

"You will oblige me by reading these few and hurried observations to the Society. I differ with Mr Rogers on many other points to which I shall have occasion to refer in a treatise *on the Stereoscope* which will soon be published. I am, &c.

"D. Brewster.

"St Leonard's College, St Andrews,
February 16, 1856."

2. Theory of the Free Vibration of a Linear Series of Elastic Bodies. Part I. By Edward Sang, Esq.

Some remarkable Specimens of Photography were exhibited.

The following Gentleman was elected an Ordinary Fellow:—

Dr Laycock, Professor of the Practice of Medicine.

The following Gentleman was elected an Honorary Fellow:—

Henry D. Rogers, Esq., State Geologist of Pennsylvania, U.S.

Monday, 3*d March* 1856.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. Observations on the Diatomaceous Sand of Glenshira. Part II. Containing an Account of a number of additional undescribed Species. By William Gregory, M.D., F.R.S.E., Professor of Chemistry in the University of Edinburgh.

The author, after referring to his former paper on this subject, stated that he had continued the investigation, and that the number of undescribed forms besides those formerly figured had proved so large, that the present paper does not conclude the subject, but that

a good many forms remain for a future communication. He added, that even now, after he had explored 600 slides of it, new forms were still occasionally found.

He then gave a list of about thirty additional *known* species, which had been noticed since the former paper was read, many of them having been last year described by himself as new fresh-water species, and others not having been yet described, but to be described and figured in vol. ii. of Smith's *Synopsis*. These are:—

Amphora membranacea.
„ hyalina.
„ salina.
Cymbella sinuata.
Amphiprora paludosa.
Campylodiscus Ralfsii.
Actinocyclus radiatus.
Actinocyclus (sp. ?) This is a species to be figured in Vol. II. of the Synopsis, but I do not know how it is named.
Actinoptychus duodenarius (new to Britain ?)
Nitzschia bilobata.
Eupodiscus tenellus, Brib. (new to Britain ?)
Navicula Westii.
„ Hennedii.
„ Pandura, Brib.
„ rostrata.
Pinnularia megaloptera.
„ biceps.
„ linearis.
„ subcapitata.
„ gracillima.
Pleurosigma distortum.
„ intermedium.
Gomphonema subtile.
Diatomella Balfouriana.
Orthosira spinosa.
„ mirabilis.

He stated that he had actually found and sketched the last two forms in this deposit three years ago, but had not been able to study them fully, till after they had been found and named, the former by Drs Greville and Balfour, and Professor Smith, the latter by Mr Okeden. He had also found both these forms in soils from South America, and gave his reasons for suspecting *O. mirabilis* to be an abnormal state of *O. spinosa*.

He then proceeded to describe the following new species, of which very exact drawings by Dr Greville were exhibited:—

1. Navicula rhombica, n. sp.
2. Navicula maxima, n. sp.

Both of these had been figured in the former paper, but were now better understood. *N. rhombica* occurs in packs, like packs of cards.

3. Navicula formosa, n. sp.
4. „ pulchra, n. sp.
5. „ Macula, n. sp.
6. „ latissima, n. sp.
7. „ quadrata, n. sp.
8. „ solaris, n. sp.
9. Navicula Hennedii, Sm., of which the deposit yields very fine specimens.
10. Navicula angulosa, n. sp.
11. „ Pandura, Brib. ?
12. „ nitida, Sm. ?
13. „ splendida, n. sp.
14. „ incurvata, n. sp.

Nos. 11, 12, 13, and 14, form a very remarkable panduriform group, the first two having entire costæ, like *Pinnularia alpina*, the last two moniliform striæ. The author, on this account, names the first, No. 11, *Navicula*, after De Briberson, and the second doubtfully, as no description of *N. nitida*, Sm., has yet appeared. The two others are quite new. The author here stated that he had found in this deposit *N. didyma* with costæ, so that he considers it possible that all these forms may belong to only one species; but the point requires investigation.

15. Navicula clavata, n. sp.
16. Pinnularia longa, n. sp.
17. „ fortis, n. sp.
18. „ Ergadensis, n. sp.
19. „ inflexa, n. sp.
20. „ acutiuscula, n. sp.
21. Stauroneis amphioxys, n. sp.
22. Cocconeis distans, n. sp., inaccurately figured in Part I.
23. Cocconeis costata, n. sp., a more characteristic specimen than that figured in Part I.
24. Cocconeis radiata, n. sp.
25. „ lamprosticta, n. sp.
26. Amphora elegans, n. sp.
27. „ rectangularis., n. sp.
28. „ obtusa, n. sp.
29. „ lineata, n. sp.
30. „ plicata, n. sp.
31. „ biseriata, n. sp.
32. „ crassa, n. sp.
33. „ Grevilliana, n. sp.

The three last form a very remarkable group, either a subgenus or a new genus. To this group belongs also *Amphora Arcus*, of which a part is figured in Part I.

34. Campylodiscus simulans, n. sp.

The author showed that this form so much resembles, in its markings, *Surirella fastuosa*, as figured in Part I., that these two genera probably form but one.

35. Campylodiscus bicruciatus, n. sp.
36. Nitzschia distans, n. sp.
37. „ insignis, n. sp.
38. Nitzschia socialis, n. sp.
39. Amphiprora minor, n. sp.
40. „ recta, n. sp.

The remaining forms will be described on a future occasion.

2. Theory of the Free Vibration of a Linear Series of Elastic Bodies. Part II. By Edward Sang, Esq.

I. The first part of this paper was occupied with the discussion of the validity of Newton's Theory of the Propagation of Sound. In order to discover the velocity of sound, Newton supposes a series of particles ranged in a straight line to be set to vibrate all equally and isochronously, but the epoch of vibration to vary gradually along the line; and he then investigates the circumstances under which such a vibration is possible. The true result of the investigation is this,—that if the two extreme particles be kept vibrating by some

external influence, and if all the intermediate particles be fairly started with the velocities appropriate to their positions in the series, the constrained vibrations of the two extreme particles, aided by the elasticities of the intermediate parts, are sufficient to maintain the vibrations of those parts.

Neither the premises of this investigation nor the conclusion have the slightest reference to the problem "*to discover the velocity of sound.*" In order to represent the conditions of this problem, we must suppose that, the row of particles being at rest, the particle at one end receives a sudden impulse, and we must seek to trace the manner in which this impulse is propagated along the chain; and it is evident that there is not one point of connection between Newton's theory and such premises.

Having failed in many attempts to separate the variables which enter into the analysis, the author of the paper was again led to consider the question by the construction of the Manchester and Liverpool railway; for the question in hand is identical in its character with this one, "*to investigate the effect of a concussion on a train of waggons connected by elastic buffers;*" but although the practical importance of the subject induced him to make more strenuous efforts, the difficulties of the integrations again baffled him. In the month of November last, however, being again led to reconsider the problem, he was so fortunate as to discover an easy method of separating the variations so as to render them integrable, and thus to bring the matter within the scope of strict analysis.

The same method is applicable to problems of a higher class. Thus if we suppose a number of planets, of which the attractions are proportional to the distances, although these attractions be not proportional to the masses of the attracting bodies, the integrations can be effected. The result of the investigation shows that such a planetary system would have as many nuclei as planets,—one of these nuclei being the centre of gravity; each of the other nuclei would describe an ellipse around the centre of gravity in its own periodic time; and thus the motion of any one planet would be the compound of as many elliptic motions, less one, as there are planets, superadded to the rectilineal motion of the centre of gravity.

It was mentioned that this is the first instance in which *the* PROBLEM *of* THREE BODIES has been resolved when the resultants of the attractions do not all pass through one point.

II. The motions of a linear elastic series form but a case of the preceding problem. It was shown that the vibration of a series of n equal bodies are compounded of $n-1$ distinct vibrations, performed in times which are proportional to the secants of the multiples of the nth part of a quadrant. These times, then, are all incommensurable, so that a perfectly elastic series of n bodies could never again return to its original state; nay, not even two of the bodies could ever again be simultaneously at the corresponding parts of their orbit.

This incommensurability of the periodic times presents a great obstacle to a theoretic estimate of the velocity with which an impulse is transmitted, since it is difficult to decide what phenomenon should be defined as constituting the transmission; and since the equations to be evolved contain the sines of angles of which the ratios are incommensurable. Thus, although the equations enable us to compute the state of the system at any prescribed time, we are unable to resolve generally the converse question,—At what time is any one body in a given state?

One very important deduction is, that a blow on one end of an elastic series evokes every oscillation of which the series is susceptible, and that, therefore, no pure or musical sound can ever be produced by a perfectly elastic body. A simple oscillation can only be produced by the concurrence of twice as many initiatory conditions as there are particles. Now there is no doubt that the vibrations of elastic bodies do resolve themselves into simple or very slightly complicated vibrations, so that the viscidity, imperfect elasticity of the parts, or some analogous quality of the material, must operate.

The time needed for the transition from an infinitely confused to a simple vibration, and the manner in which that transition is accomplished, may lead to the explanation of *consonant* sounds; and the existence of some of the higher classes of vibrations with that vibration which gives the musical pitch, may occasion the peculiar phenomena of vowel sound.

Monday, March 17, 1856.

RIGHT REV. BISHOP TERROT, V.P., in the Chair.

The following Communications were read :—

1. An Account of some Experiments on certain Sea-Weeds of an Edible kind. By John Davy, M.D., F.R.S., Lond. and Edin., &c.

The sea-weeds examined by the author, reported on in this paper, were the following :—Carrigeen Moss (*Chondrus crispus*), Dulse or Dylisk (*Rhodymenia palmata*), Sloke or Laver (*Porphyra laciniata*), Tangle (*Laminaria digitata*), Doughlaghman (*Fucus vesiculosus*).

The results, imperfect as they are, it is stated, are offered as a contribution, with the hope of inducing others more favourably situated to turn their attention to a subject hitherto, in a chemical point of view, singularly neglected.

Chondrus crispus was found to be composed of about 28·5 parts by weight soluble in cold water, of 49 soluble in boiling water, and of about 22·5 per cent. resisting both infusion and decoction. The part dissolved by boiling water had the properties of gelatine; that by cold water of mucilage.

In Dulse no gelatine was detected. Acted on by cold, followed by boiling water, it lost about 52 per cent. Its colouring matter has the property of combining with alumina, and is precipitated by this earth from its infusion.

Sloke or Laver was found to be very similar to the preceding. Acted on by cold and by boiling water it lost about 50 per cent.

Tangle also bore a considerable resemblance to the preceding, judging from the properties of its infusion and decoction. The stalk yielded less soluble matter to water than the fronds, only about 13·5 per cent.

Fucus vesiculosus lost by infusion about 16 per cent., and by subsequent decoction about 39 per cent.

In all these Algæ iodine was detected in the matter extracted by infusion and decoction, and in the residual matter : it was found also in the water used to wash the weeds, for the purpose of removing

the salt adhering, derived from the sea, in which they grew. The proportion of iodine, as indicated by testing the saline matter obtained from the ash, varied in each. It was found very abundant in tangle, with a trace of bromine, and especially in the stem. In the ash of each also a notable proportion of phosphate of lime was found, with more or less of carbonate of lime and magnesia.

In conclusion, the author offers some general remarks—1*st*, On the absence in these algæ of starch, fatty or oily matter, and saccharine matter. 2*d*, On the necessity of minute research to determine the exact nature of their several proximate principles. 3*d*, On the loss sustained by washing the weeds preparatory to their being used as food, thereby diminishing their value. 4*th*, On their value as articles of food, if the nitrogen they afford may be considered as a criterion of their nutritive power: a table is given showing the proportion of this substance in each, as determined by Professor Apjohn, exhibiting the unexpected result, that these esculent algæ are actually richer in nitrogen than flour of the first quality. 5*th*, On the advantage likely to be derived, especially by persons of the labouring class, in regard to health, from their more general use. 6*th*, On their efficacy as manures, on account of the nitrogen which they yield in the act of decomposition, and the inorganic compounds they supply to the soil. *Lastly*, On the part they perform in the economy of nature—in purifying sea-water by removing excess of carbonic acid, and probably azote—and in separating and storing up, not only most of the inorganic elements which exist in terrestrial plants, but others, especially those powerful medicinal agents, iodine and bromine, as if specially for the use of man.

2. On the Deflection of the Plumb-Line at Arthur's Seat, and on the Mean Density of the Earth. By Lieutenant-Colonel James, R.E. Communicated by Professor Forbes.

The author states that the results of the Trigonometrical Survey of Great Britain are now nearly ready for publication, and that he has deduced from them the most probable measures which they afford of the length of a meridian, and the figure of the earth.

After determining the most probable spheroid from all the astronomical and geodetical operations in Great Britain, it has been found that the plumb-line is sensibly deflected at several of the trigono-

metrical stations; but in almost every case the physical cause of such irregularity may be with probability inferred.

In the case of the station at the Edinburgh Observatory, and on the summit of Arthur's Seat, where the latitudes inferred geodetically in consistency with the entire survey are compared with the direct astronomical determinations, a deviation of the plumb-line towards the south, to the extent of between 5″ and 6″ is manifested. The exact latitudes are as follow :—

	Observed.	Calculated.	Difference.
Observatory, Calton Hill,	55° 57′ 23″·20	55° 57′ 17″·57	5″·63
Arthur's Seat, summit, .	55° 56′ 43″·71	55° 56′ 38″·44	5″·27

From this it is evident that the discrepancy occurring at the Observatory cannot be ascribed to the deflecting attraction of Arthur's Seat, where it exists almost equally. Colonel James attributes it in both cases to the effect of the hollow of the Firth of Forth to the north, together with the mass of high ground to the south, including the Pentland and Lammermoor ranges. On actually calculating the effect of the configuration of the ground within a radius of 15 miles, about 2″·6 of the deviation is accounted for; and the writer believes that the mountainous country beyond may farther sensibly increase the effect.

With a view to determine the strictly local attraction of Arthur's Seat, three stations were fixed nearly on a common meridian line, passing through the summit of the hill. These are marked N, A, and S. The station N (most northerly) is in the vicinity of St Anthony's Chapel, A is almost on the highest point of the hill, S is situated on the knoll above Sampson's Ribs. 220 double observations of stars were made at each station in September and October 1855 with Airy's Zenith Sector.

The difference of astronomical latitude of the stations N and S is 42″·56.

The difference of the geodetical latitudes is 38″·46.

The difference of these numbers, or 4″·10, measures the double deflection of the plumb-line at the two stations due to the attraction of the interposed hill.

The accurate system of contours which have been carried round the hill allows the calculation of the attraction of all its parts at the two stations N and S, to be performed with the utmost nicety, on the supposition of its being of homogeneous material. By in-

cluding the effect of all the inequalities of the ground within a radius of 6000 feet (or rather more than a mile) around each of the stations, and denoting by x the unknown ratio of the density of the hill to that of the entire globe, these equations are obtained:

Deflection at South station,	. . .	$= 4{\cdot}197\ x$ North.
„ Arthur's Seat,	. . .	$= 0{\cdot}607\ x$ South.
„ North station,	. . .	$= 3{\cdot}710\ x$ South.

by the solution of which the ratio of the density of the hill to that of the whole earth is as ·5245 to 1.*

By extending the radius of sensible attraction considerably beyond 6000 feet, and calculating the effect of the surrounding country in the same manner on the plumb-line at the three stations, this value of the relative density of the globe is somewhat modified. The ratio is then ·5348 to 1.

From direct experiments on the specific gravity of the rocks of Arthur's Seat, Colonel James infers the mean density of the hill to be 2·75 times that of water; whence the earth's density comes out

5·14,

with a probable error of 0·07.

3. On the Possibility of combining two or more independent Probabilities of the same Event, so as to form one definite Probability. By Bishop Terrot.

In this paper the author showed that, a and e being independent probabilities of the same event, the expression $a+e-a\,e$, given in the article Probability in the *Encyclopædia Metropolitana* as the value of their combined force, was erroneous. For if $a+e-a\,e$ be the probability of the occurrence of the event, then $\overline{1-a}+\overline{1-e}-\overline{1-a}\cdot\overline{1-e}$ or $1-a\,e$, is the probability of its non-occurrence. Whereas the probability of non-occurrence derived directly from the expression $a+e-a\,e$ is $1+a\,e-\overline{a+e}$.

It was then shown, that if the *ratio only* of equally probable cases in two or more probabilities were given, no definite probability could be derived from their composition; but that if the two given probabilities $\frac{p}{r}$ and $\frac{q}{s}$ indicate not merely the ratios, but the *actual*

* The outstanding abnormal deflection of the plumb-line (assumed to be equal at the three stations) amounts to 4″·72.

numbers of favourable and unfavourable cases or hypotheses, their compound force is properly expressed by $\frac{p+q}{r+s}$.

Under both of these conditions, the second given probability increases or diminishes the force of the first, according as the fraction expressing the second is greater or less than that expressing the first. When the ratios only are given, then the increase or diminution is *indefinite*. When the actual numbers are given it is *definite*.

In conclusion, it was questioned whether $\frac{1}{2}$ was a proper expression for the probability derived from total ignorance, and whether this would not be more properly expressed by the indefinite fraction $\frac{0}{0}$. It was shown that such *a priori* probability had no effect upon the force of a subsequently admitted probability.

The following Gentleman was duly elected an Ordinary Fellow:—

THOMAS CLEGHORN, Esq., Advocate.

The following Donations to the Library were announced:—

Exhibition of the Works of Industry of all Nations, 1851. Reports by the Juries on the Subjects in the Thirty Classes into which the Exhibition was divided. 4 vols. fol.—*From H. F. Talbot, Esq.*

Journal of the Proceedings of the Linnæan Society. Vol. i., No. 1. 8vo.—*From the Society.*

American Journal of Science and Arts. Vol. xxi., No. 61. 8vo. —*From the Editors.*

Journal of the Statistical Society of London. Vol. xix., Part 1. 8vo.—*From the Society.*

Quarterly Journal of the Geological Society. Vol. xii., Part 1. 8vo. —*From the Society.*

Die Fortschritte der Physik im Jahre 1852. Dargestellt von der Physikalischen Gesellschaft zu Berlin. 2^{e} Abtheil. 8vo.—*From the Society.*

Annalen der Königlichen Sternwarte bei München. B^{d} 8. 8vo.—*From the Observatory.*

Tables showing the number of Criminal Offenders in England and Wales, in the year 1854. Fol.—*From the Home Office.*

A Collection of Charts published at the Hydrographic Office, London.—*From H. M. Admiralty.*

Monday, 7th April 1856.

DR CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. On Atmospheric Manoscopy, or on the direct Determination of the Weight of a given bulk of Air with reference to Meteorological Phenomena in general, and to the Etiology of Epidemic Diseases. By Dr Seller.

The intention of the author in this communication is to recommend the daily determination of the weight, by direct means, of some considerable bulk of atmospheric air. This subject has become of interest to medical observers, owing to the belief which has arisen, on hardly sufficient grounds, that during the prevalence of epidemics the air is of greater weight than usual. The late Dr Prout, whose researches on the specific gravity of air give authority to his opinion, was led to conclude, from the greater weight observed to belong to a given bulk of air at the first outbreak of Asiatic cholera in London during the year 1832, that a malarious principle, heavier than the atmosphere itself, was at that time slowly diffusing itself through the atmosphere. Other observers in the succeeding cholera-epidemics have contented themselves with determining the daily weight of a cubic foot of air by calculation from the recorded barometric pressure, temperature, and humidity. The author endeavours to show that this last method does not meet the case. He says that, in order to detect foreign elastic matter in the atmosphere, it is necessary to weigh a certain bulk of air; for if the foreign matter be lighter than the atmosphere itself, it increases the general pressure, while it renders a given bulk of air lighter than usual; and though, when heavier than the atmosphere itself, it both increases the general pressure and the weight of a given bulk of air, yet that the former effect may escape detection, while the latter is distinct.

Dr Seller further insists that, even when no foreign elastic matter exists in the atmosphere, there is reason to doubt if the specific gravity of the air near the earth's surface is uniformly dependent on the general pressure, the temperature, and the humidity. Among the grounds for this doubt, he refers to the vast extent of the atmosphere, the infinity of circumstances constantly tending to disturb its equilibrium, the considerable periods of time required on many occasions to restore that equilibrium, if it can be said to have an ordinary equilibrium, and, in particular, to the peculiar laws, in some degree antagonistic of gravity and therefore of pressure, observed to affect the distribution of gaseous bodies, whether placed simply contiguous to each other, or already in a state of mixture. He concludes, therefore, that the only mode in which any useful result in this subject, either as respects the etiology of epidemic diseases or meteorological phenomena in general, can be obtained, is by following the example of Prout, and determining daily, by a direct process, the weight of some certain volume of air. Neither does he regard the efforts at present making by chemists to detect foreign bodies in the atmosphere by means of chemical tests as necessarily superseding the proposal to determine its daily variations of density by direct means.

Dr Seller considers the usual method of weighing air by comparing the weight of an exhausted vessel with that of the same vessel filled with air, as involving too much trouble for daily use. He suggests that a near approximation to an exact result may be made by observing the difference between the weight of a light body *in vacuo* and its weight in air; the former being a constant quantity for every place, while the latter varies in exact conformity with every change which occurs in the density of the air. The larger such a light body is, and the greater the difference of bulk between it and its counterpoise, the nearer is the approximation to an exact result, while there is the less need for extreme nicety in the process. The counterpoise, with the exception of the mere grain weights, should be capable of easy admeasurement; for example, cubic inches of a heavy metal. The sum of the weights of the body and its counterpoise *in vacuo*, diminished by the sum of their weights in air, is to be divided in the ratio of their bulks for the weight of air which each displaces. The weight of a body *in vacuo*, independently of its weight in air, can be ascertained with precision in proportion as the following data, at a certain temperature, are exactly known, viz., the weight *in vacuo* of

a given measure of distilled water, the volume of distilled water equal to the bulk of the body, the weight of the body when immersed in distilled water, allowance being made for the difference between the weight of the counterpoise *in vacuo* and in air.

The chief difficulty is to procure a body of sufficient size not too heavy for a delicate balance. It seems not improbable that a material may be found which, when formed into a globe or a drum, and filled with air merely for the sake of lightness, shall not exceed a pound in weight, and yet may be of such a size as, with a balance turning with the tenth of a grain, may, under the occasional correction of exact methods, enable those who engage in meteorology merely for the sake of occupation, to add to their register a near approximation to the daily density of air. If such a body, equal to or exceeding a cubic foot in volume, cannot be provided with the requisite qualities, namely, lightness, permanence in figure, impermeability to air and moisture, and the being susceptible of having its expansions and contractions, under changes of temperature, reduced to rule, a glass globe capable of displacing 600 cubic inches of air, with a little more pains and attention, can be made to serve the purpose recommended in this communication.

2. Researches on Chinoline and its Homologues. By C. Greville Williams. Communicated by Dr T. Anderson.

In this inquiry, which is an extension of an investigation published in the Transactions for last year, the author examines the connection which has been said to exist between chinoline and quinine, and shows that they bear no simple relation to each other. He states, also, that the supposed analogy between the action of heat on quinine and the hydrated oxide of tetramethyl-ammonium does not exist, and that the assertions which have been made regarding the possibility of the formation of quinine from the leukol of coal-tar are founded on error. He then, after showing that chinoline from cinchonine had not previously been obtained in a state of purity, gives the history and composition of the platinum, gold, and palladium salts; also the nitrate, bichromate, and binoxalate.

He describes two new classes of salts formed by the chlorides of cadmium and uranyl with organic bases, and gives the analysis of

their compounds with chinoline. Then follows a determination of the vapour density of chinoline, and an examination of the action of the iodides of the alcohol radicals on the base, and some of the products of the decomposition of the hydriodates of the ammonium bases so formed.

He also examines the chinoline series as it is obtained from coal-tar, and proves the presence, in addition to chinoline, of lepidine, and a new base, "cryptidine."

In the course of the investigation, the following compounds were analysed :—

Platinum salt, chinoline, . .	$C^{18}\,H^{7}\,N, HCl, + Pt\,Cl^{2}$
Gold, ...	$C^{18}\,H^{7}\,N, HCl, + Au\,Cl^{3}$
Palladium, ...	$C^{18}\,H^{7}\,N, HCl, + Pd\,Cl$
Cadmium, ...	$C^{18}\,H^{7}\,N, HCl, + 2\,Cd\,Cl$
Uranium, ...	$C^{18}\,H^{7}\,N, HCl, + (U^{2}\,O^{2})\,Cl$
Nitrate of chinoline, . .	$C^{18}\,H^{7}\,N, + NO^{5}\,HO$
Bichromate, ...	$C^{18}\,H^{7}\,N, + 2\,(Cr\,O^{3})\,HO$
Binoxalate, ...	$C^{18}\,H^{7}\,N, + 2\,(C^{2}\,O^{3}\,HO)$
Platinum salt, methyl-chinoline, .	$C^{20}\,H^{9}\,N, HCl, + Pt\,Cl^{2}$
Hydriodate ethyl-chinoline, . .	$C^{22}\,H^{11}\,N, + HI$
Platinum salt, ethyl-chinoline, .	$C^{22}\,H^{11}\,N, HCl + Pt\,Cl^{2}$
Hydriodate amyl-chinoline, . .	$C^{28}\,H^{17}\,N, HI$
Platinum salt, amyl-chinoline, .	$C^{28}\,H^{17}\,N, HCl + Pt\,Cl^{2}$
Platinum salt, lepidine, from coal-tar,	$C^{20}\,H^{9}\,N, HCl + Pt\,Cl^{2}$
Hydriodate ethyl-lepidine, . .	$C^{24}\,H^{13}\,N, HI$
Platinum salt, ethyl-lepidine, .	$C^{24}\,H^{13}\,N, HCl + Pt\,Cl^{2}$
Platinum salt, cryptidine, . .	$C^{22}\,H^{11}\,N, HCl + Pt\,Cl^{2}$

3. On Fermat's Theorem. By H. Fox Talbot, Esq., F.R.S.

The author gave a simple demonstration of the proposition, that $a^n = b^n + c^n$ is impossible, when $n > 2$, and either of the numbers, a, b, c, a prime number.

4. On the Transmission of the Actinic Rays of Light through the Eye, and their relation to the Yellow Spot of the Retina. By George Wilson, M.D.

In 1849 the learned Swiss philosopher Wartmann stated, in his "Deuxième Mémoire sur le Daltonisme," p. 40, that "the eye

arrests the chemical radiations which accompany the more refrangible rays." He founded this conclusion on experiments made with guaiac resin; but as this substance is by no means very sensitive to actinic influence, it seemed desirable to test the question whether the eye can transmit the chemical rays of light, by an appeal to those highly impressible *actinolytes* (as they may be called) which the recent progress of photography has revealed to us.

The necessary trials were kindly made for me by Messrs Dick and Spiller of London, and their results, which are opposed to those of Wartmann, were published last autumn in the Appendix (p. 166) to my Researches on Colour-Blindness.

I now lay upon the Society's table photographs of small objects, on glass and paper, produced by rays which, before reaching the sensitive surfaces, had traversed the transparent humours of an ox's eye. These photographs were obtained by the gentlemen I have named in the following way:—

"An ox-eye was prepared by cutting away the sclerotic until the choroid came into view; a circular aperture of one-eighth of an inch in diameter was then made through this membrane and the retina, which laid bare the vitreous humour at a point opposite to that where the light enters. The eye was then supported in the brass mounting of a photographic lens (*i.e.*, a brass tube adapted to the front of a camera), resting at the posterior end on a ring of cork which fitted tightly into the tube, and retained in front by a diaphragm, so as to permit the cornea to protrude. From the arrangement of the fittings, we are quite satisfied that no light excepting that which passed through the eye could enter the camera.

"Within the dark box, a strip of black paper, with a diamond-shaped or rhombic aperture occupying the greater part of its breadth, was extended across in front of the prepared collodion glass plate, so as to throw its image on the latter, in the event of any chemical rays finding their way to it. The camera was then pointed to the sky (the morning being bright and the sun shining), and the plate exposed for fifteen seconds. On developing with solution of sulphate of iron, a very decided picture appeared. The glass plate which accompanies this paper was the result of twenty seconds' exposure.

"The conclusion derived from this experiment, although perfectly

satisfactory to those who arranged the apparatus, is open to the objection, on the part of others, that the picture does not present any *prima facie* evidence of its being the result of rays which passed through the eye. We therefore endeavoured to copy photographically the actual image which is depicted on the retina. To do so, another bullock's eye was carefully dissected, so as to open a circular space of about three-eighths of an inch in diameter at the back of the eye, the retina was removed, and a very thin film of glass, in shape like a watch-glass, substituted for it; this supported the vitreous humour in its original position, and served also to prevent its contact with the photographic paper placed behind to receive the impression. In another trial, the retina was left untouched, without altering the ultimate result.

"Iodide of silver paper was then made sensitive to light by a wash of gallo-nitrate of silver, and used as in the Talbotype process, small squares of the wet paper being successively applied to the back of the thin glass film, and exposed for varying periods (one minute on an average) to the different objects to which the bullock's eye was presented. On developing the latent images with strong gallo-nitrate of silver, very distinct pictures were obtained *of a key* and of a *spotted window curtain.* These negative pictures are inclosed. It is thus beyond a doubt that the chemical rays penetrate the humours of the eye, and impinge upon the retina.

"Allan B. Dick.
"John Spiller."

It thus appears that the actinic or chemical rays are not arrested in their passage across the chamber of the eye; and it becomes an important question how they will affect the general surface of the retina on which they impinge, and what share they have in producing vision. Into this problem, as a whole, however, I do not purpose to enter: the question I alone consider is the change which the actinic rays will undergo when they fall upon that peculiarly organized portion of the human retina which anatomists distinguish as the "yellow spot." This "spot," almost peculiar to man, presents a diameter of about $\frac{1}{12}$th inch, and occupies the bottom of the eye, in the exact axis of its transparent humours. It is more transparent than the rest of the retina, and has long been recognized as the seat of most perfect vision in the eye of man. I have elsewhere drawn

attention to the effect which it must have as a coloured medium on the light which reaches it,* and on the actinic rays which traverse it. I wish now to carry these views a step further, in connection with the reflection of light from the choroid through the retina, which was discussed before the Society last session, in a paper "*On the Eye as a Camera Obscura*," and which, before and since, has been largely made the subject of independent inquiry by foreign and British observers. In particular, Professor Goodsir has shown, in a lecture delivered in the University of Edinburgh last June, and since published,† that it is not merely the case that light traverses the retina to the choroid, and is then reflected so as to return through the retina, but that *it is only the rays thus returned which produce a luminous sensation.* The light, therefore, which traverses the yellow spot, and is then reflected forwards on the choroidal extremities of the optically sensific constituents of the retina, must have been deprived, to a greater or less extent, of its actinic rays, before it determines a luminous sensation, unless the portion of the retina under notice differ from all other yellow transparent media known to us, in not arresting the chemical rays. If it be not in this respect exceptional, then the theory of perfect human vision may be simplified by the exclusion from consideration of the actinic rays; and one use of the yellow spot, for which it has hitherto baffled physiologists to find a use, may be to extinguish these radiations. I offer this only as a suggestion, the value of which must be determined by testing the chemical power of light after it has traversed the yellow spot,—an experiment which only those few anatomists can try who have the opportunity of examining the human eye soon after death.

I will only, therefore, remark further, in reference to the absorption of the actinic rays by the yellow spot (with which this paper is chiefly concerned), that the views of those who have described visual impressions on the retina, as phenomena of the same kind as photographic impressions on surfaces charged with salts of silver, or other actinolytes, must fall to the ground if the actinic rays of light are stopped before reaching the optically sensific constituents of the retina. The similar opinion, also, that "spectral vision," and other abnormal peculiarities of sight, are phenomena of the same kind as

* Researches on Colour Blindness, p. 83.

† Edinburgh Medical Journal, October 1855.

the development (as it is technically called) of latent photographic images, must, for the reason mentioned, be abandoned. It will still, of course, be competent to compare normal and abnormal vision with photographic effects, as phenomena displaying analogy, though not affinity.

To one other relation of the retina to light, I make the briefest reference. If only those rays which are reflected from the choroid produce, by their impact on the retina, the objective perception of light, and if the depth of tint of the yellow spot be considerable, and its colour at all homogeneous, then perfect vision must be exercised by yellow, not white light. But if this be the case, we should be unconscious of red and blue when seeing best, or at least should receive from them an impression very different from that which they occasion when they affect the general surface of the retina. I forbear, however, to speculate on this, seeking rather to direct the attention of the few anatomists who have the opportunity of investigating the subject to an examination of the chromatic as well as the actinic relations of the yellow spot, than desiring to dogmatize on either.*

P.S.—I take this opportunity of expressing my regret, that in a postscript, added after it was read, to the paper in the Transactions of the Society for last session, "*On the Eye as a Camera Obscura*," I inadvertently misstated the views of Professor Goodsir on the retina referred to in this communication, and had not an opportunity of amending the statement before the Transactions were published. I have, therefore, to request those who wish to do justice to Mr Goodsir, to consult his lecture on the Retina, published in the "*Edinburgh Medical Journal*," for October 1855.

The following Donations to the Library were announced:—

The Assurance Magazine, and Journal of the Institute of Actuaries, Vol. vi., Part 3. 8vo.—*From the Institute.*

Proceedings of the Ashmolean Society, 1855. 8vo.—*From the Society.*

* According to some eminent authorities, there is an aperture in the centre of the yellow spot. If such be the case, light may pass and repass by it without being coloured; but as such light will in both journeys fail to impress the retina, it cannot contribute to the production of a luminous sensation.

The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. N. S., No. 52. 8vo. —*From the Society.*

Journal of the Asiatic Society of Bengal. N. S., Nos. 5 & 6. 1855. 8vo.—*From the Society.*

Bulletin de la Société de Géographie. 4me Série. Tome x. 8vo. —*From the Society.*

Verhandlungen der Kaiserlichen Leopoldinisch-Carolinischen Akademie der Naturforscher. Bd xxiv., Supp. Bd xxv., Heft 1. 4to.—*From the Academy.*

Smithsonian Contributions to Knowledge. Vol. vii. 4to.—*From the Smithsonian Institution.*

Abhandlungen der Kaiserlich-Königlichen Geologischen Reichsanstalt. Band 2, 1855. Fol.

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt, 1855. No. 1. 8vo.—*From the Institute.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Bd xvii., Heft 3. 8vo.—*From the Academy.*

Coup d'œil Géologique sur les Mines de la Monarchie Autrichienne. Par Fr. de Hauer & Fr. de Fœtterle. 8vo.—*From the Authors.*

Monday, 21*st April* 1856.

SIR DAVID BREWSTER, K.H., V.P., in the Chair.

The following Communications were read :—

1. On the Prismatic Spectra of the Flames of Compounds of Carbon and Hydrogen. By William Swan, Esq.

While the prismatic spectra of the blue portions of an oil-lamp or coal-gas flame, exhibit a number of bright lines, separated by dark intervals, the spectra derived from the bright light of these flames are perfectly continuous. Apparently inconsistent results are in like manner obtained when the flames of different compounds of carbon and hydrogen are compared. Thus, lines are easily seen in the

spectrum of the flame of alcohol, which are invisible in that of the flame of oil of turpentine.

These discrepancies are shown, in the present paper, to arise from the predominance of the light of incandescent solid carbon in some flames, and its comparative absence in others: and it is also proved that in order to obtain uniform results from the flames of the various compounds of carbon and hydrogen, it is sufficient, in cases where the body contains much carbon, to convert the carbon into carbonic acid, without its previous separation in a solid form, by means of an artificial supply of air. This is conveniently effected for coal-gas by means of the Bunsen gas-lamp, which burns a mixture of gas and air; and, for other bodies, by directing a stream of air from a table blow-pipe through the flame.

When thus treated, all the compounds of carbon and hydrogen which have been submitted to experiment, were found to produce identical spectra; that of the Bunsen lamp serving as a standard of comparison.

In these spectra five principal bright lines were observed, accompanied by several smaller ones, and separated by dark intervals. One of the lines, the well known R of Fraunhofer, has been long known to coincide with the line D of the solar spectrum. Two other extremely close coincidences were discovered. One between a brilliant green line of the lamp spectrum, and the remarkable triple line *b* of Fraunhofer; and another, between a bright purple line, and the conspicuous line G of the solar spectrum.

It follows, from these experiments, that all bodies whose composition is expressed by the general formulæ

$$C_p H_r \text{ , or } C_p H_r O_s,$$

produce, in burning, perfectly identical spectra; the nature of the light being always the same, notwithstanding variations in the relative proportions of carbon and hydrogen, and the occasional presence of oxygen in the body.

2. On the Laws of Structure of the more disturbed Zones of the Earth's Crust. By Professor H. D. Rogers, of the United States.

After adverting to previous publications on the subject by himself and Professor W. B. Rogers, the author of the paper began the enunciation of the laws of structure of disturbed tracts of strata, by stating the general proposition that in all districts where the strata have been displaced from the original positions or levels in which they were deposited, they invariably have the form of one or many waves, even where, from a flatness of the undulations, they seemed to retain their original horizontality. In large areas of undulating strata, where the dips are gentle, the main or primary crust waves are very broad; but where the dips are steep, the crests of the adjacent undulations are more closely approximated, and generally the amplitude of the waves is in proportion to their flatness.

It is another prevailing feature of districts of displaced strata, that the undulations into which they have been lifted are approximately parallel, and exhibit a remarkable resemblance to those great continuous billows, which are called waves of translation. This wave-like structure was first distinctly recognised by the author and his brother in the Appalachian chain of the United States, and has been subsequently shown by them to characterize other mountain systems, such as the Jura, the Alps, and the mountainous districts of Wales and Belgium, and other countries.

Parallelism.

1. Expressing, in systematic form, the general relations of the flexures of the earth's crust to each other, the first law is that of the mutual parallelism of the waves. This prevails not only between adjacent individual flexures, but between these and the chief igneous axes of the disturbed zones, including them. The parallelism extends to the different groups of waves into which the breadth of the undulated district is divided, and subsists as well between those which are curved in their crest lines as between those which are straight. The persistency of this law of parallelism throughout the Appalachian chain, was fully exemplified in the paper. The geological maps of the United States and of Pennsylvania, soon to be published, make it obvious upon mere inspection.

2. The flexures, when the undulated belt is broad, exist in groups of waves, and the parallelism is generally more perfect between the members of a given group than between one group and another.

3. Usually where the zone of undulated strata is extensive, there are several orders of waves, as regards their dimensions, the secondary or lesser classes constituting as it were ripples on the slopes and summits of the primary or larger. These minor flexures, or subordinate rolls, are themselves parallel, but not always necessarily parallel with the principal waves upon which they lie.

Form and Gradation of the Waves.

Three essential varieties of form prevail among the great flexures of the earth's crust. 1. The most simple is that of a symmetrical wave, or one where the convex (*anticlinal*) or concave (*synclinal*) curve is of equal flexure upon both slopes. This form belongs chiefly to the flatter and broader waves, and when met with among those of steeply-inclined sides, is apt to be accompanied by an angular bending or even partial dislocation at the anticlinal or synclinal axis. 2. A second prevailing form is where one side of the wave is visibly steeper than the other. This is the normal type of flexure in the Appalachian chain, in the Jura mountains of Switzerland, and in the undulated zone of Belgium and the Rhenish Provinces. 3. The third class of flexures embraces those which exhibit an inversion or folding under of the most bent slopes of the several waves. This doubling under frequently amounts to an almost perfect parallelism of the two sides of the flexures. In such cases where the alternate convex and concave bendings are numerous, and the whole belt is closely plicated, a transverse section presents the puzzling phenomenon of strata of different ages dipping in one direction, in parallel, seemingly conformable superposition, the newer rocks underlying the older ones as frequently as they overlie them.

Conceiving a series of imaginary geometric planes to bisect the successive anticlinal and synclinal bends in a belt of undulated strata, these axis planes, as they may be called, are, in the case of the symmetrical class of waves, necessarily perpendicular; but, in the other two classes, they are inclined to the horizon, and their dip or inclination is flatter as the waves approach the form of most extreme folding with inversion. In many districts, as along the south-eastern

side of the Appalachians, and on both flanks of the Alps, these axis planes, or what is the same thing, the foldings of the rocks, incline at a very low angle, implying an excessive amount of horizontal movement at the time the strata were thus plicated and packed together.

This parallel reduplication of strata is usually attended by more or less metamorphism, amounting to that change of internal structure which is denominated cleavage; and the cleavage planes, frequently more conspicuous than the original planes of sedimentation, serve still further to conceal the flexures, and disguise the true order of superposition of the rocks.

Waves of the Crust both Straight and Curvilinear.

In the much corrugated belts, the crust waves are both straight and curvilinear. In the Appalachians there are groups of both these classes, retaining their special features throughout their entire length, which, in some instances, exceeds 100 miles. Some of the crescent-shaped waves present their convex curvature towards the region of maximum dislocation and metamorphism, while other groups are concave toward the same quarter. These different systems of waves seem to have been generated some of them from straight, others from curvilinear fractures in the earth's crust.

The Appalachian chain, regarded in the light of a long zone, or chain of groups of parallel straight and curving waves, consists of eleven sections, six of which are straight and five curvilinear, three of the latter form being convex towards the N.W., and two convex towards the S.E., the whole zone having a length of 1500, and a maximum breadth of 150 miles. Certain of the straight divisions have their anticlinal axes, or the crest lines of the undulations trending N. 15° E.; other divisions, theirs trending N. 70° E., while some of the curving sections of the chain show a deflection in the direction of their individual axes of as much as 40°. Indeed, in particular instances, the change of trend amounts to as much as 60°. So remarkable a bending without disruption, of groups of parallel anticlinals seems incompatible with the inferences of some eminent geologists, who conceive that there prevails a general relation throughout the globe between the directions of the lines and the epochs, of crust elevation; for we here find that the self-same axis, generated throughout its whole length, not merely in one geolo-

gical period, but in one brief interval of time, alters its direction to coincide successively with sundry of the different assumed systems of crust elevation.

Gradations in Flexures.

Every broad belt of undulated strata exhibits certain gradations in the form of its flexures starting from the side of maximum igneous action, as this is displayed in plutonic eruptions, or in dislocations and metamorphism. Crossing the zone, the flexures first met with are invariably of the closely plicated class, their axis planes dipping often at a low angle towards the igneous border. To these succeed more and more open waves, until, from being perpendicular, the steep far sides of the undulations become flatter and flatter in their dips, till at last they assume a slope equal and symmetrical with those of the gentler flanks. Parallel with this gradation is a progressive widening of the waves themselves, and a corresponding sinking or flattening down of the summits, until they finally disappear in imperceptible undulations. All these phenomena of gradation may be clearly discerned in every section across the Appalachian chain, traced from the S.E. towards the N.W., and a perfectly identical structure will be found to exist in the great plicated belt ranging through the Rhenish Provinces and Belgium. In truth, there is no great corrugated zone that does not display a similar law of gradation in its flexures, when these are properly traced and generalized.

Fractures in Undulated Zones.

Two classes of dislocations abound in all belts of the crust where the strata are greatly undulated. The least conspicuous, but most numerous are comparatively short faults, transverse more or less perpendicularly to the strike of the anticlinal and synclinal axes. These abound in the Appalachians and other corrugated mountain chains, and are a principal cause of the deep transvere ravines and mountain notches which intersect their ridges, and give passage to their streams. The more obvious dislocations are the great longitudinal ones coincident either with the anticlinal and synclinal axis planes, or with the steep or inverted sides of the anticlinals. A distinctive character of these great fractures is their parallelism to

the axis planes, whether they are coincident with them or not. Many of the more extensive longitudinal dislocations of the Appalachians are traceable to the rupturing of the anticlinals along their most wrenched inverted slopes. These waves are entire at their extremities, but so broken along all their intervening portions as to present only one-half of the wave form, the other half being profoundly buried with inversion under the unbroken part. Generally, in these great dislocations, the gently-dipping uninverted slope of the waves has been shoved—in the inclined plane of the fault—forward and upward upon the other inverted and crushed half, and in some instances through a great distance.

The up-driven parts having been extensively removed by erosive action, the upper strata of the overturned buried half of the wave are seen to be immediately overlapped in nearly conformable altitude of dip by the denuded lower strata of the uninverted side. Similar phenomena of the plunging of newer formations under older ones, with approximately conformable dips, meet us continually in the Alps, and other much plicated districts, and can be demonstrated to have arisen from the same cause, the upward and forward propulsion of the uninverted halves upon the inverted sides of the anticlinal waves along the great sloping planes of dislocation, into which the flexures have snapped at the time of their sudden bending.

These several laws of crust undulations, consisting of those which relate to the parallelism, form, gradation in distance, shape, and dislocation of the waves, are exemplified in detail in the paper, and by appeals to the phenomena of some of the more conspicuously corrugated tracts of Europe. Viewing, as one such zone, the undulated districts of southern Belgium, the Rhenish Provinces, the Westphalian coal-field, the chain of the Ardennes, and the Hundsruck, Taurus, and Hartz ranges, and referring for proofs to the descriptions and maps of M. Dumont and other geologists, who have described these provinces in more or less detail, the author shows that this belt displays all the phenomena of structure and gradation described by him as so conspicuous in the Appalachians of America. Sections transverse to this region from S.E. to N.W. will be found to exhibit precisely the same succession, from closely folded flexures with metamorphism through steep normal waves, to broad, open, and approximately symmetrical ones.

The structure of the Jura chain of Switzerland likewise exhibits proofs of the same laws. There the crust waves closely resemble those of the Appalachians—the whole chain is composed of several groups of flexures, differing in their direction or strike; but the waves of each group display a remarkable parallelism among themselves. Very few of the flexures exhibit actual inversion of their steeper sides. It is remarkable that the steep slopes of the great waves of the Jura face the Alps; and those nearest the Alps, or on the borders of the valley of Switzerland, are more compressed than those on the far side of the chain,—their more inclined flanks, for example in the Weissenstein, dipping even perpendicularly, or a little past this, into partial inversion. This southward thrust of the crests of the Jura anticlinals would seem to imply a movement from the north, and not from the igneous axis of the Alps, or probably from both quarters, at the period of the production of the flexures.

The Alps themselves show the same general structural phenomena as the other plicated zones described, but under more complex conditions. This much convulsed mountain system contains but few waves of the open or normal type, consisting, except on its outer flanks, of many very close plications of the strata. When these foldings are carefully studied and structurally connected with each other, the whole chain appears to be composed of two or more central parallel igneous crests, and each flank of these mountain ranges of a belt of closely compressed waves. Each of these plicated zones or Alpine slopes displays the axis planes of its flexures dipping in towards the centre of its own chain, the flexures nearest the igneous axis plunging at a lower or flatter inclination than those more remote. High in the slopes of the chain, where denudation has removed the largest part of the originally present upper formations, only the synclinal folds of these remain preserved. These are the so-called V's of the tertiary and jurassic beds, pinched in between the closely folded anticlinals of the gneissic, and other older rocks. The inward dip of nearly all the beds of both slopes of the Alps, thus occasioned by the completeness of the folding and the outward thrusting of the anticlinal parts of the flexures, is the obvious cause of that fan-like feature of dip of the entire chain, which has recently excited so much discussion among geologists. Cleavage of the rocks, and a superinduced crystallization parallel to the cleavage

planes, contribute not a little, the author conceives, to the illusive appearance of a general inward dip of all the strata, even the newest, under the older formations of the high igneous crests of the chain; for both the cleavage planes and the crystalline foliation observe a very constant parallelism in the direction of their dip to the dip of the axis planes of the flexures.

Slaty Cleavage.

It is now a good many years since Professor Sedgwick and other geologists announced the important general fact, that the structure called *slaty cleavage* pervades the altered strata affected by it in directions independent of their bedding or laminæ of deposition; that these planes of cleavage are approximately parallel to each other over large spaces of country, however contorted the dip of the rocks; and that where the cleavage is well developed in a thick mass of slate rock, the strike of this cleavage is nearly coincident with the strike of the beds. Professor Phillips, in 1843, added to this rule a still more comprehensive and exact expression—that the cleavage planes of the slate rocks of North Wales were always parallel to the main direction of the great anticlinal axes. Since 1837, these phenomena of the close parallelism of the cleavage planes with each other, and with the main axes of elevation, have been observed and recorded by Professor W. B. Rogers and the author of this communication; and in 1849 the author submitted to the American Association for the Advancement of Science a communication on the analogy of the ribbon structure of glaciers to the slaty cleavage of rocks, in which he stated what he deems the true law of cleavage of a district of undulated and plicated strata,—namely, that the cleavage dip is parallel to the average dip of the anticlinal and synclinal axis planes, or those planes which bisect the flexures. The generality of this rule was shown by sections exhibiting the flexures and cleavage in the Appalachians, in the Alps, and in the Rhenish Provinces. Subsequent observations in other localities have confirmed the universality of this law; and the recent description of the Devonian strata in the south-west of Ireland by Professors Harkness and Blyth still farther tend to illustrate and establish it. In their paper in the *Edinburgh New Philosophical Journal* (October 1855), they not only recognise an agreement between the

strike of the cleavage planes and that of the several rolls (or anticlinals) which affect the island of Valentia, but they show, that while the cleavage dip is southerly, the anticlinal "curves have been pushed over in a more or less northerly direction," inverting the carboniferous limestones and coal measures. Their general statement is, that the cleavage structure of rocks does not result from the simple rolling of the strata, but from this cause, combined with a considerable amount of pressure, and this latter force acting from the south, has pushed over the strata in a series of oblique curves to the north, and given to the inclined cleavage more or less of its southern dip. They further support the deductions of Mr Sharp, "that there has been a compression in the mass in a direction everywhere perpendicular to the planes of cleavage, and an expansion of the mass along these planes in the direction of a line at right angles to the line of incidence of the planes of bedding and cleavage." But from this view of the mechanical nature and the direction of the force engendering cleavage the author of this communication begs leave to dissent.

A second general law is, that where the cleavage is fully developed, and the anticlinal and synclinal flexures are also conspicuous and very sharp, the cleavage planes immediately adjoining these bendings are not parallel to the axis planes, but radiate partially from them, in a fan-like arrangement, upward in the anticlinals, and downward in the synclinals. This aberration from the normal direction is, furthermore, not symmetrical upon the opposite sides of the geometric axis planes, but is usually greatest upon the inverted or steep sides of the waves.

A third prevailing relation of the cleavage planes is—their tendency to deviate from the normal direction of parallelism to the axis planes, in order to conform partially to the direction or dip of the strata; and as in every belt of uniform flexures closely plicated with inversions, the uninverted, or normal dips, greatly exceed the inverted ones in breadth, there prevails a lower inclination in the planes of cleavage than belongs to the planes bisecting the flexures.

There is yet another law modifying cleavage, dependent upon the mechanical texture, and possibly the chemical composition, of the strata. In formations composed of alternations of the coarser mechanical rocks, such as siliceous grits and conglomerates, with the finer-

grained argillaceous beds, such as slates, shales, or marls, the coarser beds are unaffected by cleavage, while the finer-grained ones are often pervaded by it. Indeed, there appears a strict proportion between the degree of intimate fissuring of the rocks by cleavage and the degree of comminution of the particles. Connected probably with this interruption in the propagation of the cleavage, the author has observed another modification of the cleavage planes,—namely, that they tend to curve a little from the normal direction, in the fine-grained argillaceous beds, approximating to parallelism with the surfaces of bedding of the adjoining coarser mechanical deposits, as they approach them, showing in a transverse section, a kind of gentle sigmoid flexure. This fact is well illustrated in the cleavage-traversed rocks at the base of the anthracite coal-formation of Pennsylvania, where the red shales alternate with the lower beds of the coal-sustaining conglomerates and coarse sandstones. These remarkable facts seem sufficient of themselves to refute the hypothesis, somewhat in favour at present, of the purely mechanical origin of the cleavage-producing force; for we cannot conceive how a mechanical force either of compression, or of tension, transmitted, as necessarily it must have been, very equally, through parallel layers of coarse and fine material, should have exerted no fissuring action the moment it reached the surface of the coarser beds, and yet have been able to cleave into thin parallel slaty laminæ the whole body of the finer-grained argillaceous strata. One would more naturally suppose that the less finely-aggregated softer mud rocks or shales would have been even less easily fissured into sharp cleavage joints than the more massive and better cemented grits.

Foliation.

The relations of the foliation or crystalline lamination of metamorphic strata to the cleavage planes and the planes of stratification, are next dwelt on. Two facts may be stated of foliation, which possess perhaps the constancy of general laws. One of them is, that this structure, as it is seen in gneiss and mica schist, observes, when the strata are not traversed by cleavage, an approximate parallelism with the original bedding. The author of this paper has beheld apparent exceptions to this rule in several localities near Philadelphia and elsewhere in the United States; and others have been noticed in Europe by Mr D. Sharpe and other good observers,

but all of them can be reconciled to the general fact, and reduced, it is conceived, to the one comprehensive law,—that the planes of foliation, or the laminæ formed by the crystalline constituents of the foliated rocks are parallel to the planes or waves of heat which have been transmitted through the strata. Whenever large tracts of the gneissic rocks retain a nearly horizontal undisturbed position, the foliation is almost invariably coincident with the stratification; and in this case the wave of heat producing the crystalline structure can only have flowed upwards through the crust, invading stratum after stratum in parallel horizontal planes. Again, when injections of granite have lifted the gneissic strata, the crystalline lamination is generally seen to be parallel to the plane of outflowing temperature.

The other general rule is, that the foliation is parallel, or approximately so, to the cleavage, wherever these two structures occur in the same mass of rocks. This fact, recorded by Darwin, of the gneissic rocks and clay slates of South America, has been noticed likewise by Mr D. Sharpe, Mr David Forbes, Mr Sorby, and other geologists in Great Britain, and by the author in many localities in Southern Pennsylvania. An interesting instance of such parallelism of the foliation to the cleavage, in the last-named region, tending to show convincingly that both phenomena are the consequences of one species of force, or but different degrees of development of the same molecular or crystallizing agency, is presented in the great synclinal trough of the lower Appalachian limestone, north of Philadelphia. On the north side of this trough, the primal and auroral rocks, Cambrian or Lower Silurian, dip S., over a wide outcrop, at a very regular angle of about 45°. On the south side, they have been lifted into, and even a little beyond, the perpendicular position, so that the synclinal axis plane of the belt dips at an angle of 65° or 70° to the south. Neither formation shows cleavage structure on the northern side of the valley, the limestone being there of an earthy texture, and in thick massive beds; but on the south, or upturned side, this limestone is altered into a mottled blue and white crystalline marble, and is pervaded with cleavage planes, dipping at angles of 70° and 80° southward. Many parts of the rock are like a foliated calcareous gneiss, thin laminæ of mica and talc dividing the slate-like plates of the marble. What is especially worthy of notice is, that the foliation of the mica and talc, composing some of the thin partings between the original

beds of the limestone, is itself very generally parallel to the cleavage in the adjoining calcareous rock. Indeed, wherever the cleavage is excessive, the mass throughout becomes, by introduction of fully developed talc and mica between its laminæ, a true foliated stratum. An especial interest attaches itself to cases of this kind, from their showing, in the two contrasted conditions of the absence and presence of metamorphism in the two opposite outcrops of the self-same synclinal stratum, that both effects, cleavage and foliation, have originated at the same time, and from one and the same cause, and are in truth but different stages of the same crystalline condition, superinduced on the mass by high temperature, at the period of its elevation.

The above enunciated general facts of the prevailing parallelism of the foliation to the cleavage, is but a corollary of the still more general relationship already expressed of the parallelism of the resultant planes of crystallization to the waves of heat, which have produced the metamorphism.

Theoretical Views.

Theory of the Flexion and Elevation of Undulated Strata.

The wave-like structure of the Appalachian and other undulated zones has been attributed by the author and his brother W. B. Rogers, in their communications to the American Association in 1842, and to the British Association in the same year, to an actual undulation of the supposed flexible crust of the earth exerted in parallel lines, and propagated in the manner of a horizontal pulsation, from the liquid interior of the globe. They have supposed the strata of such a region " to have been subjected to excessive upward tension, arising from the expansion of molten matter and gaseous vapour, and this tension relieved by parallel fissures formed in successive lines through which such elastic vapour escaped, the sudden removal of the pressure adjacent to the lines of fracture, producing violent pulsations on the surface of the liquid below. This oscillating movement would communicate a series of temporary flexures to the overlying crust, and these flexures would be rendered permanent (or keyed into the forms they present) by the intrusion of molten matter. If, during this oscillation, we conceive the whole heaving tract to have been shoved (or

floated) bodily forward in the direction of the advancing waves, the union of this tangential with the vertical movements may explain the peculiar steepening of the front side of each flexure, while a succession of similar operations will accomplish the folding under or inversion seen in the more compressed districts." They think that no purely vertical force, exerted either simultaneously or successively along parallel lines, could produce a series of symmetrical flexures, while a tangential pressure, unaccompanied by a vertical force, would result only in an imperceptible bulging of the whole region or in irregular plications, dependent on local inequalities in the amount of the resistance. The alternate upward and downward movement necessary to enable a tangential force to bend the strata into a series of regular parallel subsiding flexures was, they conceive, of the nature of a pulsation such as would arise from a succession of *actual waves* rolling in a given direction beneath the earth's crust. Successive feeble tangential movements could not agree either in direction or amplitude, nor is it easy to imagine how they could shift their positions through a series of parallel axis lines, nor how, when renewed, they could return always to the same lines to build up the conspicuous flexures. These oscillations of the crust, to which the undulated strata are attributed, have been, they conceive, of the nature of the earthquakes of the present day;—earthquakes being, as they have demonstrated, a true pulsation of the flexible crust of the globe, propagated in parallel low waves of great length and amplitude, with prodigious velocity, from lines of fracture, either conspicuous volcanic axes, or half-concealed deep-seated fissures in the outer envelope of the planet.

Theory of the Origin of Cleavage Structure.

Concerning the cause of slaty cleavage, the author of the paper has adopted the explanation originally proposed by Professor Sedgwick, that it is due "to crystalline or polar forces acting simultaneously and somewhat uniformly, in given directions, on large masses having a homogeneous composition." And following up the further suggestion in extension of this idea, ingeniously proposed by Sir John Herschel, that this molecular force was of the nature of an incipient crystallization, and has been developed in the particles by their being heated to a point at which they could begin to move among

themselves, or upon their own axes, he has endeavoured to show that, whether the cleavage-cut strata have been much disturbed or not, the cleavage planes invariably approximate to parallelism with those great planes in the crust, which give indications of having been the planes of maximum temperature. It has been already stated, in the present paper, that the cleavage dip is parallel to the average dip of the anticlinal and synclinal axis planes bisecting the flexures. Now it is easy to prove that these axis planes, and the inverted parts of the flexures, are just those portions where the greatest crushing, fissuring, and displacement of the strata must have occurred, and where the highly heated pent-up volcanic steam, gases, and liquid mineral matter would find their chief channels obliquely upward towards the surface. Not to attempt the application of this view in detail, it will suffice at present to state, that every plicated belt of strata may be regarded as having, at the time of its folding and metamorphism, contained from this cause a series of alternate hotter and colder planes or belts, arranged in parallel oblique dip. These planes of temperature are supposed to have acted to polarize the particles of the strata in corresponding parallel planes, by transmitting through the half-softened mass parallel waves of heat, stimulating the molecular crystalline forces ever resident in mineral matter in planes parallel to the generating surfaces.

3. On a Property of Numbers. By Balfour Stewart, Esq. Communicated by Professor Kelland.

4. Analysis of Craigleith Sandstone. By Thomas Bloxam, Esq., Assistant-Chemist, Industrial Museum, with a Preliminary Note by Professor George Wilson.

One object of the Laboratory of the Industrial Museum is the prosecution of investigations likely to throw light on the economic value of materials employed in the useful arts. It has been impossible this winter to do more than make a small beginning by instituting an examination into the properties of certain of our building stones; and as the results obtained in the case of the sandstone of Craigleith Quarry have an interest for geologists as well as for architects and builders, they are laid before the Society, as all similar results of any

scientific value will be in future. The entire investigation will be published in the course of the summer.

It is necessary to remark here that the following experiments were made solely upon the coarser variety of the stone, known as Common or Bed Rock; the finer portions, not yet submitted to chemical investigation, being called Liver Rock, most probably from the closeness of its grain.

The objects which I had chiefly in view in the course of the following inquiry were, the exact chemical composition of the stone; the extent to which it contains other insoluble substances than silica; the amount of substances soluble in pure water, in water saturated with carbonic acid, and in water containing the mineral acids. The extent to which the stone absorbs and retains water, was also object of investigation, and the coaly matter which occurs at intervals in it was analysed.

The whole of the analyses were made by Mr Thomas Bloxam, the assistant-chemist in the Laboratory of the Industrial Museum, who spent much pains on the inquiry. From what follows it will be seen that the Craigleith sandstone, as taken in cubes for building, is nearly all silica, but that it contains in addition small portions of alumina, lime, magnesia, iron, and, occasionally, a hitherto unsuspected ingredient, oxide of cobalt, which Mr Bloxam has distinctly indicated. In addition to those substances, black particles occur disseminated even through the whitest and most solid portions of the stone, which in the majority of cases appear to be coaly matter, but are sometimes in greater part carbonate of the protoxide of iron, coloured by an admixture of coal.

The condition in which those bodies occur in the stone is as important as their relative amount; but it is not so easily ascertained. Much of the silica is present in more or less perfect grains of quartz; a small portion occurs as the chief ingredient of scales of mica, and also probably as felspar; and according to Mr J. Napier of Partick, Glasgow, a certain amount of the silica is in combination with alumina as clay. Mr Napier experimented by reducing the stone to fine powder, and washing it on a flannel filter, which retained the silica, and allowed the clay to pass through. Proceeding in this manner, and receiving on a weighed filter paper the muddy water which passed through the flannel, Mr Bloxam found that 9·33 per cent. of substance remained on the paper after drying at 212°. This may pro-

visionally be called clay, of which it consists in small part; but till it is analysed, it would be premature to discuss its nature. Mr Napier's observation, however, that sandstones contain clay, is an important one, especially in reference to their power to retain moisture, and continue long damp in the walls of buildings.

The iron which occurs so generally in sandstones, and is so important an ingredient, from its tendency to stain the stone after it is quarried and exposed to the air, is certainly present in different chemical conditions. It has been generally assumed, I think, to occur in carboniferous sandstones as bisulphuret; but it appears to be chiefly present in the Craigleith rock as carbonate of the protoxide, the form in which it has always been recognised as prevailing in the shales accompanying such sandstones. As already mentioned, the protocarbonate of iron occurs in detached portions, coating and dividing certain strata of the stone from each other; but it is not on this circumstance that I found the conclusion stated above, but on the following results:—1000 grains of the stone, finely powdered, were suspended in cold distilled water, and a stream of washed carbonic acid gas sent through the liquid for an hour. The water passed through a filter quite transparent; but upon boiling became troubled, and deposited carbonates of lime and magnesia, peroxide of iron, and a little silica. Of these substances the peroxide of iron was the most abundant, and it had plainly been dissolved as protocarbonate. The probability, accordingly, is that the metal existed as carbonate in the sandstone; but it may have been present as metal or as black oxide, though scarcely as bisulphuret, and certainly not as peroxide. The point of most practical interest, however, is, that rain-water, containing, as it always does, carbonic acid, is able to dissolve iron as well as lime and magnesia from exposed sandstones; so that we may always expect to find them colour more or less from the solution and subsequent peroxidation of the iron which they contain.

It was not found possible to remove the whole of the iron from the powdered sandstone by the action of carbonic acid water, for after it had exerted its full effect, hydrochloric acid, if boiled on the powder, extracted iron as peroxide, unaccompanied by protoxide.

The action of other solvents on the stone is as follows:—Distilled water boiled upon it in fine powder acquired a notable quantity of lime, a small quantity of sulphuric acid, and a trace of iron. Minute quantities of the alkalies, of magnesia, and of silica were doubt-

less also present, but were not sought for. Hydrochloric acid boiled upon the powdered stone yielded a solution in which protoxide and peroxide of iron, alumina, lime, and magnesia, were found in marked quantity; and traces of manganese and cobalt, along with potassa, soda, and silica, in small quantities.

From those results it will be seen that the purest water can dissolve a certain amount of substance from Craigleith sandstone; that if charged with carbonic acid it will disintegrate it further; and that if containing free mineral acids, as the rain-water of towns occasionally does, it will decompose it still further.

In connection with those results, it is important to notice the extent to which the stone absorbs and retains water, points on which Mr Napier has already made valuable observations. The specimens selected for the following trials had an average sp. gr. of 2·443.

A piece weighing 3506·1 grains, which had been received from the quarry in the month of November 1855, and remained for about a month in a room without a fire, was kept at 212°, till it ceased to lose weight; the loss was equivalent to 5·7 fluid ounces per cubic foot.

A similar piece, weighing 4597·95 grains, was immersed in distilled water at 58°, till it ceased to gain weight. The surface-moisture was then allowed to evaporate, and the stone weighed. The gain was equivalent to 3·8 imperial pints per cubic foot.

According to Mr Napier, a sandstone acquires much more moisture if allowed to absorb it by capillary attraction from one part of its surface, than if entirely immersed in water, but upon making the experiment in the way he describes, the difference, by capillary attraction, was comparatively small; the whole gain being 4·2 imperial pints on the cubic foot. On the other hand, when the stone was immersed in water under the bell jar of the air-pump plate, and the air withdrawn, the ultimate gain in weight amounted to 6·2 imperial pints per cubic foot. The error of those who hope to render buildings dry by constructing their walls of solid sandstone, will be sufficiently apparent from these facts. The numerical results obtained by Mr Bloxam are added in full.

Analysis of Craigleith Stone.

Specific Gravity.	Action of Water on the Stone.	Action of Carbonic Acid Water upon the Stone.	Action of Hydrochloric Acid upon the Stone.	Loss on drying at 212° F.	Water absorbed by continued immersion.	Water absorbed by Capillary Attraction.	Water absorbed under the Air-Pump.
2·443	6 ounces water boiled on 305·70 grains of stone for 1 hour and 40 minutes, dissolved from it ·27 of a grain.	Dissolved Protoxide of Iron, Lime, and Magnesia.	Dissolved Protoxide of Iron, Peroxide of Iron, Oxide of Cobalt, Manganese, a trace, Alumina, Lime; Potassa and Soda, in small quantity.	5·7 Fluid ounces per cubic foot.	3·8 Imperial pints per cubic foot.	4·2 Imperial pints per cubic foot.	6·2 Imperial pints per cubic foot.

COMPOSITION IN 100 PARTS.

Silica,	96·95
Peroxide of Iron and Alumina,	2·30
Water,	·23
Lime, Magnesia, Oxide of Cobalt and Alkalies,	·52
	100·00

The following Gentleman was duly admitted an Ordinary Fellow:—

James Clerk Maxwell, Esq., Fellow of Trinity College, Cambridge.

The following Donations to the Library were announced:—

Report of the Yellow Fever Epidemic of British Guiana. By Daniel Blair, M.D. 8vo.—*From the Author.*

Physical and Geographical Map of India. By G. B. Greenough. 8vo.—*From the Executors of the late G. B. Greenough.*

Théorie de l'Antagonisme et de la Pondération. Par M. Alexandre Gérard. 8vo.—*From the Author.*

London University Calendar, 1856. 12mo.—*From the University.*

Proceedings of the Botanical Society of Edinburgh, 1855. 8vo.—*From the Society.*

The Quarterly Journal of the Geological Society. Vol. ii., part 4. 8vo.—*From the Society.*

Flora Batava. Afleverings 177 & 178. 4to.—*From the King of Holland.*

Abhandlungen, herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. 1ster Band, 2te, Lieferung. 4to.—*From the Society.*

Memorias de la Real Academia de de Ciencias de Madrid. Tome 1 and 2. 8vo.—*From the Academy.*

Positions moyennes pour l'époque de 1790,0 des étoiles circompolaires, dont les observations ont été publiées par Jérome Lalande dans les Mémoires de l'Académie de Paris de 1789 et 1790. Par Ivan Frederenko. 4to.—*From the Editor.*

Ueber Dr Wichmann's Bestimmung der Parallaxe des Argelanderschen Sterns. Von W. Döllen. 4to.—*From the Author.*

Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Nov. 1855—Avril 1856. 4to.—*From the Academy.*

Monday, 3*d March* 1856.

Monday, 17*th March* 1856.

Monday, 7*th April* 1856.

Monday, 21*st April* 1856.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

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